

# SCIENCE

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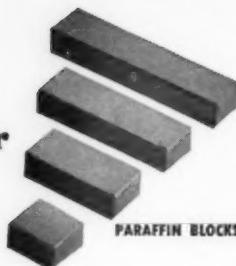
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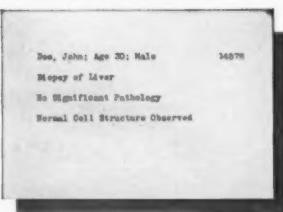


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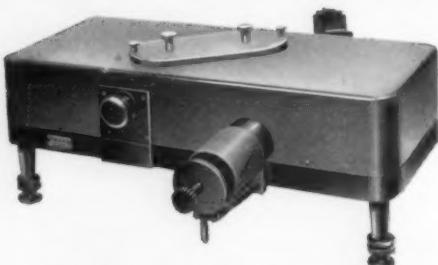
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## The Small Foundation

On a single recent day the Ford Foundation announced grants totaling \$500 million to increase faculty salaries and to improve medical education and practice. This is philanthropy on the grand scale, a scale so grand that the amount exceeds the combined capital resources of the two foundations next in order of size after the Ford Foundation.

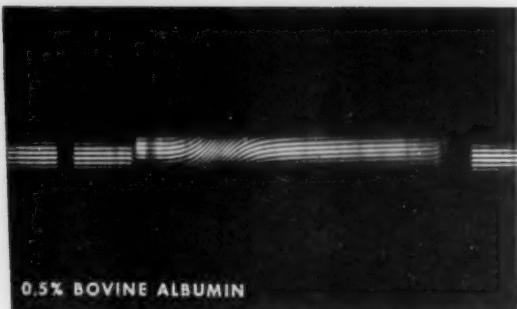
Great wealth makes possible such a broadside attack and permits a foundation to support a number of different efforts. A small foundation must necessarily use a different method of making its resources effective, for trying to do on a small scale what the great foundations can do on a large scale might merely dissipate its resources and would certainly accomplish little that is distinctive. If it is to be a significant factor in the philanthropic picture, the small foundation must look about for a worth-while task on which it will not duplicate the work of larger foundations. The Bok Peace prize of a quarter of a century ago was a dramatic illustration of the distinctive use of relatively small resources and made the sponsoring American Foundation known to many who otherwise would never have heard of it.

The American Foundation was established in 1924 by the late Edward W. Bok with an endowment of \$2 million to be used for charitable, scientific, literary, and educational purposes and to promote the welfare of mankind. It has recently completed a study that is distinctive and has special significance for science: publication of a two-volume work entitled *Medical Research: A Midcentury Survey*. In preparation for 15 years, the report was given a ceremonial launching by the foundation on 15 November and was published the following day by Little, Brown and Company.

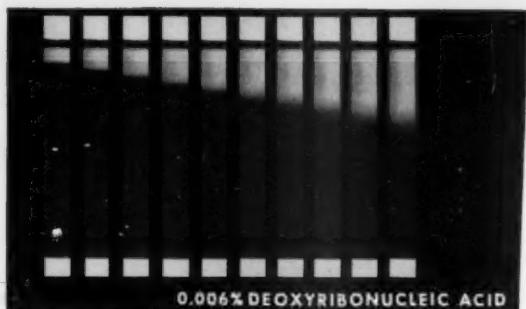
The theme of the report is that the best hope of solving major outstanding medical problems lies in fundamental research in the basic sciences. The first volume is a critical analysis of contemporary agencies interested in medical research. The second takes nine illustrative problems—for example, cancer, rheumatic conditions, and alcoholism—and examines the relationships between basic research and their eventual solutions.

Obviously such a work drew upon the resources of many organizations and had the assistance of many persons. Special help came from a consulting committee of 26 eminent scientists and clinicians. But the lion's share of the credit for a well done job, the consultants say, belongs to Esther Everett Lape and her assistants on the American Foundation staff. The consultants were enthusiastic in their praise for Miss Lape's skill in organizing and interpreting, accuracy of reporting, and clarity of writing.

The report is directed primarily to the medical practitioner, but it is also, as one critic wrote, "lucid enough for the layman and detailed enough for the scientist in the field." Limited funds could have been used in other ways than to write such an impressive stock-taking and direction-pointing analysis as this report is. But certainly the impact on medical thinking and quite likely the contribution to the solution of major medical problems will be much greater than could have been achieved by an equal amount of money spent in more customary and less imaginative ways.—D. W.

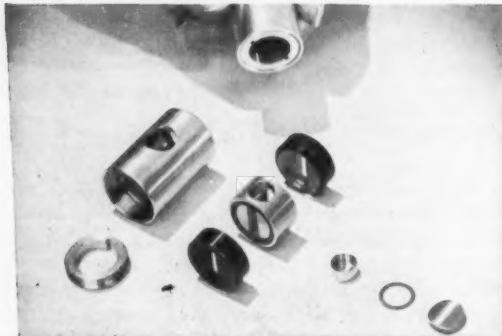


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## Science and People

Warren Weaver

Because I feel so deeply and so strongly concerning what I have to say on the subject of science and people, I shall run the risk of being dully pedagogical and state my plan at once. First, I am going to ask what successes man has had in his various endeavors and inquire why science seems to bulk so large among these successes. I am going to recount some foolish ideas concerning science that have arisen partly because of its successes. I am going to contrast these with a series of statements that seem to me more accurately to describe science and its relation to life. The main conclusion will be that science belongs to all the people, and that this fact presents the American Association for the Advancement of Science with a great opportunity and a great duty.

## Man's Major Successes

Think of the various major tasks to which men have, over the ages, addressed themselves. They have sought food, warmth, shelter, and other guards against the physical assaults of nature. Each individual or group has also sought protection against attack from the rest of mankind.

Men have tried to understand the physical universe. They have striven to apply this body of understanding to attain control of and to exploit this power over physical nature.

Men have tried to understand organic nature—how it evolved, and how individual organisms reproduce, grow, and function. They have sought health of

body. They have tried to understand the nature of mind, of consciousness, of memory, of the learning process. They have endeavored to manage personal relationships within family groups, the village, the tribe, the state, the nation, and the world at large. They have attempted social and eventually political organization at all levels of inclusiveness and complexity, and they have tried to understand human behavior as it affects all these interrelationships.

Men have created methods for ownership of property and have elaborated systems of customs and laws in an attempt to protect individuals and serve society. They have recorded history and have attempted to understand it. They have, at great cost and with high dedication, tried to strike a balance between regulation and liberty.

Men have sought to enrich life through development of the pictorial arts, literature, music, drama, and the dance. They have created systems of logic and metaphysics and have tried to analyze the nature of knowledge and reality. They have formulated codes of esthetics and morals and have contemplated the purpose and meaning of life.

In this vast and interrelated range of concerns and activities, where do the successes lie? What things have men really done well?

Each man is entitled to his own answer, but my own reply would go as follows. Probably the most conspicuous, the most universally recognized, and the most widely applied success lies in the understanding and control of the forces of physical nature. Coupled with this, I would place the progress that has been made—even though it is but a start—in the understanding of organic nature.

But along with these two I would want

to bracket, without attempting to suggest an order of importance, two other major successes. The first of this second pair of successes is to be found in the grandeur and practicality of the principles of personal conduct that have been enunciated by the great religious leaders. I would suggest, for example, that the Ten Commandments, the Golden Rule, and the rest of Sermon on the Mount have the generality within their realms that Newton's laws of motion have in theirs, plus the fact that no religious Einstein has found it necessary to insert correction terms of higher order.

The second further success that seems of major proportion is to be found in the degree to which life can be and has been enriched by the arts. Thus it is my own conviction that the poet has done a job that science must thoroughly respect, and perhaps should envy.

In listing only these four major successes, some real unfairness may have been done to our social advances. Granting all the confusions and troubles that greet us with each issue of the newspapers, it remains true that man has made great progress in sorting out his human relationships. The cry "Who goes home?" which still adjourns the House of Commons, reminds us that not too long ago members required armed escort to protect them from the brigands who lurked between Westminster and the City. The constitutional experience of the American republic is impressive evidence that society does not always blunder. His Majesty's loyal opposition—the difference between political opposition and treason—is the basic treaty of political life in widening areas of the world. If science has made great contributions to man's well-being, the institution of contract has, in an unobtrusive way, made it possible. And it is deeply satisfying to recall that the daily lives of most people are saved from Hobbes' jungle by the presumption of good faith that infuses our relationships with one another.

To return to the four major successes, it seems interesting to note certain features that show how disparate they are. The first success—that of the physical sciences—is in a field where logic and quantitative measurement are dominant. The second—the dawning light of understanding of animate nature—is far less advanced, and it involves factors that are certainly nonquantitative and may

Dr. Weaver, retiring president of the AAAS, is Vice President for the Natural and Medical Sciences of the Rockefeller Foundation. This article is based on his AAAS presidential address, which was given in Atlanta 28 Dec.

well prove alogical. The third—the perfection of the codes of personal conduct—is curiously and unhappily more a matter of theory than of practice. I believe it was Chesterton who remarked that no one knows whether Christianity will work because no one has ever tried it. As an ex-mathematician, I would point out that one single clear exception proves that a presumptive general rule is incorrect, and I would therefore say that Chesterton's remark is characteristically vivid and interesting, but that it is false. The fourth success—man's enrichment of his life through the arts—presents features that are baffling to a scientist. Indeed, I am not sure that the word *success* really applies here, for success connotes a bad start and good progress. But the arts, as a previous AAAS president has pointed out, seem to constitute an almost completely nonaccumulative part of experience. Rutherford had a great natural advantage over Faraday, and he over Gilbert; with respect to electric phenomena, both theory and the techniques of experimentation kept advancing, and each step was built on top of the preceding one. But Emily Dickinson had no advantage over Sappho. Each simply had words, the challenge of beauty, and the ineffable genius to condense, purify, and universalize experience.

### Success of Physical Science

Of these four major successes, I believe it is rather clear that the most tangible and obvious is the success of physical science. And this is an instance in which success and danger are close companions, as they often are. I do not refer here to the danger—ominous as it is—that science has unleashed forces that can physically destroy us. I refer to the more subtle danger that this success may mislead us concerning the real nature of science and its relationship to the rest of life and thus destroy something that is in the long run more important than a factory or a city, namely, our sense of value.

What made possible the great success that the physical sciences have experienced, particularly during the last century and a half? The explanation appears actually to be rather simple. *Physical* nature, first of all, seems to be on the whole very *loosely coupled*. That is to say, excellently workable approximations result from studying physical nature bit by bit, two or three variables at a time, and treating these bits as isolated. Furthermore, a large number of the broadly applicable laws are, to useful approximation, *linear*, if not directly in the relevant variables, then in nothing worse than their second time derivatives. And finally, a large fraction of physical phenomena

(meteorology is sometimes an important exception) exhibit *stability*: perturbations tend to fade out, and great consequences do not result from very small causes.

These three extremely convenient characteristics of physical nature bring it about that vast ranges of phenomena can be satisfactorily handled by linear algebraic or differential equations, often involving only one or two dependent variables; they also make the handling *safe* in the sense that small errors are unlikely to propagate, go wild, and prove disastrous. Animate nature, on the other hand, presents highly complex and highly coupled systems—these are, in fact, dominant characteristics of what we call organisms. It takes a lot of variables to describe a man, or for that matter a virus; and you cannot often usefully study these variables two at a time. Animate nature also exhibits very confusing instabilities, as students of history, the stock market, or genetics are well aware.

If the successes of physical theory had remained limited to those highly useful but none the less essentially simple situations covered by two variable equations such as Ohm's law in electricity, or Hook's law for elastic deformation, or Boyle's law for volume and pressure of gases, or even to the vastly greater range of dynamic phenomena that are so superbly summarized in Newton's second law of motion, then it seems likely that mankind would have preserved a reasonable, take-it-or-leave-it attitude toward science. But two further things occurred.

Physical science pushed on to much more subtle and more complicated realms of phenomena, particularly in astrophysics and in atomic and then nuclear physics. And it kept on having successes. Second, physical science (and remember that nowadays it is not really useful to discriminate between physics and chemistry) began to be applied more and more to certain limited sorts of problems of animate nature. Biochemistry, to take a very conspicuous example, began to deal successfully with phase after phase of the happenings within the individual cells of living creatures.

At the same time, of course, scientific theories kept getting more and more complicated and technical. Not only were they generally formidable to the public at large—scientific experts themselves had increasing difficulty in understanding anything outside their own specialties.

### Superstitions

All this has tended to create a set of superstitions about science. These seem to be rather widely adopted by the public, and some of them even have adher-

ents among scientists! These superstitions go something like this:

Science is all-powerful. It can just do anything. If you doubt this, just look around and see what it has done. A procedure known as "the scientific method" would in fact, if we only used it, solve all the problems of economics, sociology, political science, esthetics, philosophy, and religion. And the reason why science has been so successful, and the basis of confidence that it can go on to do anything whatsoever, is that science has somehow got the real low-down on nature and life. It has found out how to capture absolute truth, exact fact, incontrovertible evidence. Its statements are just "mathematically true," and in the face of that, you had better be confident and respectful, even if you are confused.

But science (to continue the superstitions) cannot be understood by ordinary folk. It is too technical, too abstruse, too special, and too different from ordinary thinking and ordinary experience. There is a special small priesthood of scientific practitioners; they know the secrets and they hold the power.

The scientific priests themselves are wonderful but strange creatures. They admittedly possess mysterious mental abilities; they are motivated by a strange and powerful code known as "the spirit of science," one feature of which seems to be that scientists consider that they deserve very special treatment by society.

Now these are dangerous misconceptions about science. If they were wholly untrue, if they were total and complete nonsense, then one could confidently await the general recognition of their fraudulent nature. But there is just enough apparent and illusive evidence in favor of these statements to give them an unfortunate vitality.

### Alternative Statements

Let me list as briefly as I can a set of alternative statements which I believe to be more reasonable and accurate.

1) Science has impressively proved itself to be a powerful way of dealing with certain aspects of our experience. These are, in general, the logical and quantitative aspects, and the method works superbly for linear and stable physical problems in two or three variables. The physical universe seems to be put together in such a way that this scientific approach is exceedingly successful in producing a good, workable, initial description. And with that kind of solid start, physical science can then safely proceed to elaborate more sophisticated theories.

2) We simply do not yet know how far these methods, which have worked so well with physical nature, will be suc-

cessful in the world of living things. The successes to date are very impressive. One feature after another that previously seemed to fall in a special "vital" category has usefully yielded to biochemical or biophysical attack. But it is also the case that we have as yet made only a beginning. How far the logical-quantitative method will succeed here, one would be rash to forecast, although the prospects do indeed seem extremely promising.

3) We have made small beginnings at extending the scientific method into the social sciences. Insofar as these fields can be dealt with in terms of measurable quantities, they seem to present closely intercoupled situations that can very seldom usefully be handled with two or three variables and that often require a whole host—for example, W. Leontief's input-output analysis of the U.S. economy deals with some 50 variables and regrets that it does not handle more. Science has, as yet, no really good way of coping with these multivariable but nonstatistical problems, although it is possible that ultrahigh-speed computers will inspire new sorts of mathematical procedures that will be successful in cases where the effects are too numerous to handle easily but not numerous enough or of suitable character to permit statistical treatment. If we try to avoid the many-variable aspect of the social sciences by using highly simplified models of few variables, then these models are often too artificial and oversimplified to be useful. The statistical approach, on the other hand, has recently exhibited—for example, in the stochastic models for learning—new potentialities in the field of human behavior.

4) It is, incidentally, not at all necessary that the particular analytic techniques of the physical sciences be forced upon biological or social problems with the arrogant assumption that they can and should make unnecessary other types of insight and experience. During the recent war, an extremely useful collaboration was developed, known often as operations analysis, in which reasoning of a mathematical type was applied to certain aspects of very complicated situations, but with no expectation that judgment, experience, intuition, or a vague sort of general wisdom would be displaced or superseded—rather only that these would be aided by whatever partial light could be furnished by quantitative analysis.

5) An important characteristic of science, which we must note in passing, is its incapacity to be impractical. The most far-reaching discoveries and the most widespread useful applications flow regularly out of ideas that initially seem abstract and even esoteric. These ideas arise out of the unguided and free ac-

tivity of men who are motivated by curiosity or who, even more generally, are thinking about scientific problems simply because they like to. The way in which apparently aimless curiosity stubbornly refuses to be foolish and leads to important goals doubtless seems strange or even incredible to some persons. The eventual usefulness of the initially impractical is widely held to be a very special feature of science, but I am not so sure of this. I think that apparent impracticality is more generally important than we are inclined to suppose.

6) Science presents the kind of challenge that attracts to it young men and women who tend to have a rather high degree of a certain kind of intelligence. Since this particular kind of intelligence is relatively easy to recognize and measure, and since many other types are subtle and illusive, even though perhaps more important, we tend to adopt this one type as the norm. In addition, this particular type of intelligence leads rather promptly to tangible results. These circumstances lead to the conclusion, which is then something of a tautology, that scientists are more intelligent than other people. This may or may not be true; more important, however, it may be neither true nor untrue in the sense that the attempted comparison is meaningless.

7) However, despite their appearing to be so bright, scientists are not special creatures: they are people. Like lots of other people, they are good at their own tasks. Off their jobs they seem, as Shylock remarked in another connection, "to be fed with the same food, hurt with the same weapons, subject to the same diseases, healed by the same means, warmed and cooled by the same winter and summer" as other men are. When you prick them, they do indeed bleed.

A. V. Hill, while he was president of the British Association for the Advancement of Science, stated: "Most scientists are quite ordinary folk, with ordinary human virtues, weaknesses, and emotions. A few of the most eminent ones indeed are people of superlative general ability, who could have done many things well; a few are freaks, with a freakish capacity and intuition in their special fields, but an extreme naivete in general affairs. . . . The great majority of scientists are between these groups, with much the same distribution of moral and intellectual characteristics as other educated people."

8) One rather accidental fact has led many to think that scientists are strange and special, and this is the fact that scientists often use a strange and special language. Science does find it desirable to use very many technical words, and it has indeed developed, as a matter of saving time, a sort of language of its own.

This gives to science an external appearance of incomprehensibility that is very unfortunate. The public need not think itself stupid for failing intuitively to grasp all this technicality. Indeed, what has developed is not so much a language as a series of very specialized dialects, each really understood only by its inventors. "On faithful rings" is not a sociological discussion of marriage but an article in modern algebra. The "Two-body problem for triton" is not mythology but physics: a "folded tree" is not a botanical accident but a term in telephone switching theory.

9) If scientists are human, so also is science itself. For example, science does not deserve the reputation it has so widely gained of being based on absolute fact (whatever that is supposed to mean), of being wholly objective, of being infinitely precise, of being unchangeably permanent, of being philosophically incapable and unchallengeable. There seem still to be persons who think that science deals with certainty, whereas it is the case, of course, that it deals with probabilities. There seem still to be persons who think that science is the one activity that deals with truth, whereas it is the case, of course, that—to take a very simple example—"the true length of a rod" is so clearly not obtainable by any scientific procedure that, insofar as science is concerned, this "true length" remains a pleasant fiction.

I could document this particular point at length, but will restrict myself to three quotations from the relatively mature fields of physics, astronomy, and mathematics.

Edmund Whittaker said of theoretical physics: ". . . it is built around conceptions; and the progress of the subject consists very largely in replacing these conceptions by other conceptions, which transcend or even contradict them."

Herbert Dingle, in his retiring address as president of the Royal Astronomical Society, said: "The universe . . . is a hypothetical entity of which what we observe is an almost negligible part. . . . In cosmology we are again, like the philosophers of the Middle Ages, facing a world almost entirely unknown."

Alfred North Whitehead has stated: "While mathematics is a convenience in relating certain types of order to our comprehension, it does not . . . give us any account of their activity. . . . When I was a young man, . . . I was taught science and mathematics by brilliant men; . . . since the turn of the century I have lived to see every one of the basic assumptions of both set aside."

10) These quotations indicate that the ablest scientists themselves realize the postulational and provisional character of science. Perhaps not so widely recognized or accepted is the extent to which the

development of Western science, rather than constituting a uniquely inevitable pattern, has been influenced by the general nature of Greco-Judaic culture, including especially the standards, arising within that tradition, of what is interesting and important.

Confronted by the totality of experience, men select the features that seem interesting and important—and the criteria for interest and importance arise not just or even primarily within scientific thought, but rather within the entire cultural complex. One then seeks to find a way of ordering this selected experience so that the end result is acclaimed as satisfying and useful—again as judged within the total culture. This process has different possible beginnings and different possible procedures; so, of course, it has different possible end results. Clyde Kluckhohn has remarked, "What people perceive, and how they conceptualize their perceptions is overwhelmingly influenced by culture." H. M. Tomlinson said, "We see things not as they are, but as we are."

If, for example, a culture almost wholly disregards physical suffering, considers the present life an unimportant episode, and places a very high premium on prolonged mystic contemplation, then this viewpoint regarding values does more than, for example, underemphasize modern scientific medicine (using all these words in the Western sense). It produces something that is different *in kind*; I know of no criteria that justify calling one kind good and intelligent, and the other poor and ignorant.

Chang Tung-San, a Chinese philosopher, has said: "Take Aristotelian logic, for example, which is evidently based on Greek grammar. The differences between Latin, French, English, and German grammatical form do not result in any difference between Aristotelian logic and their respective rules of reasoning, because they belong to the same Indo-European linguistic family. Should this logic be applied to Chinese thought, however, it will prove inappropriate. This fact shows that Aristotelian logic is based on the Western system of language. Therefore we should not follow Western logicians in taking for granted that their logic is the universal rule of human reasoning."

If this general line of thought seems to you either interesting or improbable, I urge you to read some of the fascinating papers of Benjamin Lee Whorf and of Dorothy D. Lee on the value systems and the conceptual implications of the languages of various American Indian tribes. Whorf, for example, points out that the Hopi Indian language "is seen to contain no words, grammatical forms, constructions or expressions that refer directly to what we call *time*, or to past,

present, or future, or to enduring or lasting, or to motion as kinematic rather than dynamic. . . . At the same time the Hopi language is capable of accounting for and describing correctly, in a pragmatic or operational sense, all observable phenomena of the universe."

11) The ten preceding numbered comments concerning certain general characteristics of science all contribute, I believe, to a major conclusion—that science is a very human enterprise, colored by our general ideas, changeable as any human activity must be, various in its possible forms, and a common part of the lives of all men.

Indeed, even the impressive methods that science has developed—methods which sometimes seem so formidable—are in no sense superhuman. They involve only improvement—great, to be sure—of procedures of observation and analysis that the human race has always used. In the appeal to evidence, science has taught us a great deal about objectivity and relevance, but, again, this is refinement of procedure, not invention of wholly new procedure.

In short, every man is to some degree a scientist. It is misleading that a tiny fraction of the population is composed of individuals who possess a high degree of scientific skill, while most of the rest are indifferent or poor scientists. This creates the false impression that there is a difference in kind, when it is actually only one of degree.

If, when a window sticks, you pound it unreasonably, or jerk so hard that you hurt your back, or just give up in ignorant disgust, then you are being a poor scientist. If you look the situation over carefully to see what is really the matter—paint on the outside that needs cutting through, or a crooked position in the frame—then you are being a good scientist.

Even primitive men were scientists, and in certain aspects of accurate and subtle observation and deduction it would probably be hard to beat the ancient skilled hunter.

Indeed, one important contrast between the savage and the professor is simply that modern scientific methods make it possible to crystallize our experience rapidly and reliably, whereas primitive science does this clumsily, slowly, and with much attendant error. But it is, after all, well to remember that ephedrine is the active principle in an herb, Ma Huang, that has been empirically employed by native Chinese physicians for some 5000 years. Certain African savages when they moved their villages did take with them to the new location some dirt from the floor of the old hut. Moreover, it is true that they said that they did this to avoid the anger of their gods who might not wish them to move, fooling

them by continuing to live on some of the same ground. But the fact remains that by this process they brought to the new location the soil microorganisms that continued to give some degree of protection from certain ailments. We quite properly honor Fleming and Florey, but Johannes de Sancto Paulo, a medical writer of the 12th century, did prescribe moldy bread for an inflamed abscess. "We are all scientists," Thomas Huxley said, because "the method of scientific investigation is nothing but the expression of the necessary mode of working of the human mind."

### Science as a Human Activity

Let us now back away from the trees and look at the forest. Where have we arrived in this discussion?

I have just listed 11 points that, in my judgment at least, fairly characterize science as a universal human activity. These comments do not support the concept of science as some sort of super creed, magical and mysterious as it is all-powerful, arrogant from its successes, and avid to invade and conquer, one after another, all the fields of human activity and thought. This viewpoint does not justify the notion that science is so special as to be unique, as well as so curious as to be incomprehensible. This does not depict scientists as strange creatures who are in one sense so objective, judicial, and precise as to be incredible, and in another sense so apart from life as to be selfish and sinister. This does not set up quantitative analytic Western science as the only valid way in which man may approach and interpret experience.

On the contrary, these descriptive comments picture science as the servant of man, not his master; and as a friendly companion of art and of moral philosophy. This is a science that is the way it is because man wants it to be that way. It is a natural expression of both his curiosity and his faith.

If the public could be brought to understand and appreciate this position concerning science and scientists, I do not think that so many persons would harm this great enterprise of ours with a combination of mistrust, fear, and overestimation. I do not think that so many would treat scientists one-third of the time as amusing but beneficial eccentrics, one-third of the time as sorcerers, and one-third of the time as irresponsible rascals. I do not think that so many would view scientists as careless dabblers with danger, or as a selfish minority that, to quote a nationally syndicated columnist, "hold they are an extra special group not tied down by the obligations and rules under which the rest of us work. Hundreds of them are now bellyaching about the Oppenheimer verdict and saying it ruins

their morale and makes them hard to get. What goes with those birds?" Or consider another newspaper writer who opened one of his columns with the sentence, "We Americans have been confronted with an arrogant proposition that persons presuming to call themselves intellectuals, and particularly those who claim the title of scientist, are a superior cult entitled to deference or even homage from the common man." One of our greatest universities takes a sound and courageous stand, and a newspaper writer complains, "Harvard has a peculiar fondness nowadays for putting security and the safety of the nation second to their fancy ideas of importance." If some speak out against the climate of fear resulting from the stupidities and iniquities of what is misnamed as the security system—doubly misnamed since it is not a system and does not achieve security—then their protest is labeled, as it was by Eugene Lyons in the *Saturday Evening Post*, as "the mock-heroic posture of this close-knit band of Cassandras"; he insultingly adds that these protesters do not themselves seem to have suffered, for "not one of them has as yet been muzzled, lynched, or denied his due royalties."

Anti-intellectual views such as these are widely expressed in those newspapers that combine a wide circulation with a narrow intellectual viewpoint, in some very popular national magazines, and even, one reports with shame, by highly placed persons in Washington.

It is hardly necessary to argue, these days, that science is essential to the public. It is becoming equally true, as the support of science moves more and more to state and national sources, that the public is essential to science. The lack of general comprehension of science is thus dangerous both to science and to the public, these being interlocked aspects of the common danger that scientists will not be given the freedom, the understanding, and the support that are necessary for vigorous and imaginative development. It is, moreover, of equally grave importance that science understand itself.

There are persons who are pessimistic concerning the prospects of materially improving the public understanding of science, and even the understanding that one branch of science has of the other branches. If one subscribes to the falsities and exaggerations that I stated in the first part of this article, then he could properly be pessimistic. If, on the other hand, he accepts the broader, more liberal, more human and humane view that I have advanced here, then—or at least so it seems to me—he can be very optimistic.

When David Brewster, a century and a quarter ago, was one of the prime movers in founding the British Association for the Advancement of Science, he said, "The principal objects of the Society would be to make the cultivators of science acquainted with each other, to stimulate one another to new exertions—

to bring the objects of science ... before the public eye and to take measures for advancing its interests and accelerating its progress."

This is a challenge which our own Association has always sought to meet. It is a challenge which, at this moment in history, requires renewed zeal and ever-renewed patience. Speaking of the present-day scientist, J. Bronowski has said, "Outside his laboratory, his task is to educate us in what goes on inside it, and to give it a meaning for us. In a world in which statesmen as much as voters are ignorant of the simplest implications in science, this is a formidable responsibility . . . [the scientist] has no other choice today but patiently to become a teacher, in a world in which distrust and prejudice are free. . . . There is no alternative to an informed public opinion; and that can exist only where scientists speak to voters and voters accept their responsibility, which is to listen, to weigh, and then to make their own choice."

If, as I believe, the sciences and the arts are lively and noncompetitive partners in the business of life, it is appropriate that we close, not with a scientist, but with a great artist. "Our privacy," Faulkner says, "has been slowly and steadily and increasingly invaded until now our very dream of civilization is in danger. Who will save us but the scientist and the humanitarian. Yes, the humanitarian in science, and the scientist in the humanity of man."

## L. L. Thurstone and the Science of Human Behavior

Louis Leon Thurstone was born in Chicago, Illinois, on 29 May 1887. He received his M.E. degree from Cornell University in 1912 and his Ph.D. from the University of Chicago in 1917. In 1912 he served as assistant to Thomas Edison. From 1912 to 1914 he was instructor in engineering at the University of Minnesota. From 1915 to 1920 he rose from assistant to professor and department head at Carnegie Institute of Technology. He remained as department head until 1923, when he accepted a position

as psychologist with the Institute of Government Research in Washington, D.C. In 1924 he was appointed associate professor of psychology at the University of Chicago and in 1928 he was promoted to professor of psychology, a position that he held until his retirement in 1952. In 1938 he was awarded the Charles F. Grey distinguished service professorship at the University of Chicago. During this year he also founded the Psychometric Laboratory. He served as its director until his retirement. He has held visiting pro-

fessorships in several European universities. After his retirement from the University of Chicago, he moved his Psychometric Laboratory to the University of North Carolina, where he continued his research and publication.

Thurstone was the leading figure in the organization of the Psychometric Society in 1935 and the establishment of *Psychometrika*, which was first published in 1936. He was a member of numerous scientific societies and held high offices in many of them, including the presidency of the American Psychological Association in 1933. His contributions to science are recorded in numerous published articles and in many monographs and books.

It is said that a scientist may count his life a success if he advances but a little the frontiers of knowledge in his own discipline. Louis Leon Thurstone did much more. He explored, charted, and cultivated vast new domains. Early in his career he recognized that there can be no true science without measurement. Beginning with the classical psychophysical methods, he developed psychological scaling techniques and applied them to

the measurement of attitudes. Among his contributions in this area are the law of comparative judgment and the successive intervals technique. His work on absolute scaling stands as a classic whose vast potentialities for the assessment of mental development still remain to be fully exploited.

Perhaps his outstanding contributions arose from his recognition that neither psychology nor any other science can advance very far if the primary variables of the discipline are not specified first. Beginning with the pioneer work of Charles Spearman, Thurstone made many important contributions to the theory and practice of multiple factor analysis, whose fundamental role in psychology, he emphasized repeatedly, is to define the variables of human behavior. The centroid method that he developed has been by far the most widely used computational technique in factor analysis. The concept of simple structure in factor analysis, as a basis for finding invariant solutions, was uniquely Thurstone's contribution. In spite of the early opposition to the concept by some of the more conventional mathematical statisticians, both theoretical and practical considerations through the years have demonstrated the fundamental importance of the concept. In recent years more rigorous analytic procedures have been developed for rotating an arbitrary factor matrix to simple structure. Indeed, one of Thurstone's most recent contributions is a technique of rotation that appears to be amenable to the more formal and analytic mathematical methods.

His notion of second order general factors permitted a *rapprochement* between his own emphasis on common factors and Spearman's concept of a general factor of intelligence. His preference for generalized oblique rotational procedures and his techniques for deriving first order general factors from second order general factors have far-reaching implications for the unification and generalization of major existing factor theories, which even today appear not to be fully appreciated.

To imply that Thurstone won all the engagements in the crucial issues of factor analysis theory and technique is not quite correct. The problem of communalities in factor analysis still remains a lively issue. But Thurstone kept the spotlight trained on this controversial problem and made major contributions toward its eventual solution. In any case, he was always generous to those who disagreed with him on the communality question provided that they were even moderately

well-informed on the technical and theoretical issues involved.

Although the major part of Thurstone's efforts were concerned with the fundamental problems of measurement and identification of the variables in a discipline that was sadly lacking in both, he also made important contributions in more specialized areas. Among these were his efforts to quantify and rationalize theoretical and experimental approaches to the problems of learning and motivation.

Notwithstanding Thurstone's basic contributions to science in general and psychology in particular, he was in no sense an ivory-tower psychologist. In a very real sense, his major contributions consisted of bringing psychology out of the ivory tower. He often remarked that it was the sterility of classical psychophysics that led him to work on the measurement of attitudes of ordinary human beings in real-life situations. This, in turn, motivated the development of his measurement and scaling theories and techniques.

He demonstrated repeatedly throughout his scientific career that productive and useful basic research comes from attempts to solve the problems of real people in a real world. For him, the dichotomy of pure versus applied psychology did not exist. Once, in his presence, a well-known person was referred to as an industrial psychologist. He remarked, a little impatiently, "There is no such thing as 'industrial psychology.'" He had little respect for the conventional rubrics of psychology. For him, considerations of scientific rationale and methodology were of prime importance. It was also of prime importance that the problems come from life itself, but it was not scientifically relevant whether the problems came from industry, a military establishment, the clinic, the school room, or the college campus. The numerous psychological instruments that he developed for the evaluation of special aptitudes, primary mental abilities, and various aspects of temperament are merely the natural outgrowth of his basic research in measurement and in the identification of primary variables; they justify his unwillingness to dichotomize scientific activity into pure and applied.

Even though Thurstone had a great respect for the role of mathematics in scientific research, it was always clear that he regarded both mathematics and statistics as nothing more than useful and faithful servants. Under no circumstances would he tolerate the slightest evidence of insubordination on their part. Some

have protested that his formulations might be modified to fit existing models. Thurstone entertained no compromise for such proposals. If the servant could not solve the problem, the master must improvise as best he could until such time as the servant could develop adequate proficiency for the task at hand. But Thurstone would not hesitate to oversimplify a problem for the sake of reaching a practical solution. He insisted that a major principle of scientific method not only permits but insists on the oversimplification of hypotheses as a basis for parsimonious description and prediction.

Although Thurstone was willing to go to considerable lengths to oversimplify his hypotheses, he was always scrupulous in avoiding falsification or unfair selection of the experimental data for testing the hypotheses. In fact, even though he was generous with those who disagreed with him on points of theory, methodology, and interpretation, he had no time whatever for those who were lax in their selection of data or for those who might suggest any laxness in this respect on his part.

Thurstone was consistently patient with and tolerant toward those who showed a genuine interest in the development of psychology as a quantitative rational science. He had a rare knack for putting at ease students who were shy or had difficulty in communicating their ideas. He would listen carefully in the hope of discovering students with ideas, and he was generous in his encouragement of anything that had the remotest resemblance to a novel or productive suggestion. His own style in lecture, discussion, and writing was clear, lucid, and unambiguous, but he made no pretense of being a flowery speaker or writer. In fact, he had a great facility for penetrating highly technical jargon or beautifully written prose to discover whether it covered up a dearth of ideas. For those who concealed a lack of ideas with an imposing verbal façade he had neither patience nor generosity.

When Louis Leon Thurstone died on 30 September 1955 at the age of 68, his contributions left psychology a far more respectable science than it was when he entered it; but equally important, he also left many well-marked signposts pointing out the directions of further research that will continue to advance the development of psychology as a quantitative rational science.

PAUL HORST

Department of Psychology,  
University of Washington, Seattle

*Genius begins great works, labor alone finishes them.—JOUBERT.*

## News of Science

### Ford Aid to Education

The following statement was issued by President Arthur S. Adams of the American Council on Education concerning the announcement of the Ford Foundation that it will make grants totaling \$500 million to increase faculty salaries in 615 private colleges and universities, to improve and expand services in 3500 privately supported hospitals, and to strengthen instruction in privately supported medical schools.

"The Ford Foundation has made December 12, 1955 a historic date both for higher education and for American philanthropy. The grants are of sufficient size to become a very real force in improving the level of compensation for college faculties and hence the quality of instruction in private institutions of higher learning across the country. Even more important is the fact that the trustees of the Foundation have perceived a fundamental need and have moved to meet it by supporting the normal operations of existing colleges and universities. Now that the Ford Foundation has so dramatically led the way, we can confidently expect that other donors will to an increasing degree help, in the words of Henry Ford II, 'to strengthen American education at its base—the quality of teaching.'"

### AAAS 50-year Members

The following AAAS members were elected as 50-year members during the association's annual meeting in Atlanta, Ga.

Section A-Mathematics: William C. Brenke, Charles O. Gunther, Egbert J. Miles.

Section B-Physics: Henry M. Brock, Elizabeth R. Laird, A. Hoyt Taylor.

Section C-Chemistry: Howard B. Bishop, William Hamlin Cady, Benjamin S. Merigold, James A. Newlands, Frederick W. Schwartz, William Gabb Smeaton, Michael Xavier Sullivan, Edgar Theodore Wherry.

Section E-Geology and Geography: Eliot Blackwelder, J Harlan Bretz, Frederick A. Camp.

Section F-Zoological Sciences: Cornelius Betten, Webster Chester, Gideon

S. Dodds, Louis Hussakof, Albert Hazen Wright.

Section G-Botanical Sciences: Mintin A. Chrysler, Claude Wilbur Edgerton, Roland M. Harper, Raymond J. Pool, Laetitia Morris Snow.

Section H-Anthropology: William K. Gregory, Lawrence Waters Jenkins.

Section N-Medical Sciences: George Bachr, Israel Simon Kleiner, Warren H. Lewis, Arthur N. Tasker, Frederick H. Verhoeff.

No section affiliation: Walter K. Gannong.

### AAAS Socio-Psychological Prize

Yehudi A. Cohen of the department of psychiatry, Albert Einstein College of Medicine, is the first recipient of the AAAS \$1000 Socio-Psychological prize. The award was announced on 28 Dec. during the AAAS annual meeting in Atlanta, Ga.

Cohen's entry was entitled "Food and its vicissitudes: a cross-cultural study of sharing and nonsharing in 60 folk societies." Cohen examined and confirmed the hypothesis that in those societies in which infants and young children are fed whenever they cry for food, or ask for food, the adult members of the society will share their food and wealth with other persons. Conversely, in societies in which infants and young children are fed only on a fixed schedule, or in which there is restraint or deprivation with respect to food, the adults will not share their food or wealth with others.

Of course, there were subsidiary hypotheses and other variables, dealing, for example, with the social and geographic distances separating members of the society. Nevertheless, Cohen found that the hypotheses he was testing were confirmed by the reports of the 60 folk societies on which he was able to secure adequate reports.

### AAAS Theobald Smith Award

ROBERT A. GOOD, American Legion heart research professor at the University of Minnesota Medical School, received the Theobald Smith award of the AAAS during the association's meeting

in Atlanta, Ga., 26-31 Dec. Good, who was a Markle Foundation scholar in medical sciences from 1950 to 1955, has conducted research in the following areas: natural and acquired resistance to gram-negative endotoxins; gammaglobulinemias and hypergammaglobulinemias; rheumatic fever; acute-phase reactions; immunology and hypersensitivity reactions; and hematology.

### Science Reprint Prices Increased

Owing to the larger page size of the new format of *Science*, there will be a slight increase in the price of reprints beginning with the issue of 6 January 1956. Authors and institutions who send payment before receiving a reprint order blank or a bill from Business Press should inform themselves of the new prices.

### Encouraging Scientific Talent

One hundred thousand new scholarships are needed immediately to conserve the nation's intellectual resources at the 18-year-old level, according to a report made public on 11 Dec. by the College Entrance Examination Board. In addition, the report said, there is urgent need for a revitalized program of guidance to insure that another 100,000 high-school graduates of superior ability acquire the desire for advanced education that they now lack.

Entitled *Encouraging Scientific Talent*, the report was prepared by Charles C. Cole, Jr., assistant dean of Columbia College, with the assistance of several education specialists. The report, and the study preceding it, were commissioned by the College Entrance Examination Board. Some of the background studies were supported by the National Science Foundation.

Insufficient financial backing and lack of motivation to attend college are given by the report as the chief reasons why each year 200,000 American high-school graduates in the upper 30 percent bracket of ability are lost to the colleges. The 400-page survey shows that this loss of talent is especially serious in the light of today's shortage of scientists and engineers.

To reach his findings, Cole engaged the Educational Testing Service to conduct research on the vocational aspirations and college and financial plans of talented high-school graduates of 1955. A random sample of 32,750 graduates, or 2.6 percent of the public school seniors in the nation, was used, and these were administered an aptitude test. Then, questionnaires were filled out by the students scoring in the top 30 percent on the test. From the questionnaires

came not only the important fact that 200,000 students of college ability did not intend to enroll in colleges during the present academic year, but also a body of other data as well.

### Edison Foundation Awards

■ The Thomas Alva Edison Foundation inaugurated its presentation of annual awards to encourage more wholesome influences for youth in the mass media at a dinner that was held on 13 Dec. at the Waldorf-Astoria Hotel, New York. Awards that were given for encouraging the interest of young people in science and in scientific and engineering careers were as follows: the best science film for youth, *The African Lion*, Disney Studios; the best science television program for youth, *Mr. Wizard*, Don Herbert of the National Broadcasting Company; and the best science radio program for youth, *Adventures in Science*, Watson Davis of Science Service.

Two other awards that relate to science were the one that was given for the best children's film, the Swedish film *The Great Adventure*, and the special citation that was made to the American Broadcasting Company for outstanding work in drawing public attention to the shortage of scientists and engineers.

### News Briefs

■ The U. S. Food and Drug Administration has granted permission for the use of Aureomycin as a preservative for uncooked poultry. This is the first time use of an antibiotic has been permitted on a food. Approval was given when no more than seven parts per million of Aureomycin remain on treated uncooked poultry. The decision to allow this amount of residue was based on evidence that cooking of poultry destroys this concentration of the antibiotic.

■ The first technological research center in Colombia has been established in Bogotá with the aim of broadening the nation's economic structure. The center was set up by the Agricultural Industrial and Mining Credit Bank of Colombia, with the aid of Armour Research Foundation of Illinois Institute of Technology.

■ Dag Hammarskjold, Secretary-General of the United Nations, on 8 Dec. sent to President Eisenhower a copy of the first of the 16 volumes of the Proceedings of the International Conference on the Peaceful Uses of Atomic Energy to arrive from the printers. He has likewise sent a copy to Homi J. Bhabha of India. This first volume to be published is vol. 3 on power reactors.

■ The Soviet Union has legalized abortion for the first time in almost 20 years, according to an announcement on 30 Nov. in the government newspaper *Izvestia*. There has been a new annual population increase of 3 million persons that has more than offset the wartime depopulation.

Abortion in the Soviet Union has had a varied history. Between the Bolshevik Revolution and 1936, abortion was freely practiced, especially in major cities. With the onset of a more conservative trend, a legal ban was rigidly enforced. At present, it is felt that the government's drive to increase the birth rate through bachelor's taxes, family allotments, and other devices has met with success.

### Scientists in the News

EDGAR S. MCFADDEN, agronomist at Texas A & M Agricultural Experiment Station, was awarded the John Scott medal for his origination and development of the first rust-resistant bread wheat. The award is administered by the Philadelphia Board of Directors of City Trusts and is given to "ingenious men and women who make useful inventions."

It has been stated that because of McFadden's work, 25 million people are eating who otherwise would be dead or dying of starvation and that during the war years he saved American farmers an estimated 400 million dollars. McFadden received the medal, accompanied by a premium of \$1000, on 27 Dec. during the AAAS annual meeting in Atlanta, Ga. Presentation was made at the close of the general symposium on Atomic Energy and Agriculture.

EDMUND W. SINNOTT, dean of the Yale University Graduate School and president of the AAAS in 1948, will retire on 30 June. Sinnott, a scientist, educator, and author, is a specialist in botany. In recent years he has become widely known for his attempts to synthesize the results of scientific research and religious thought into a unified philosophy, a philosophy that evaluates the role and responsibilities of scientists in modern life.

Sinnott is a graduate of Harvard University. He joined the Yale faculty in 1940 as Sterling professor of botany and chairman of the university's botany department. Five years later he became the first director of the university's Division of the Sciences, and at the same time assumed the post of director of the Sheffield Scientific School. Despite his heavy administrative load, he has continued to conduct research and to hold a limited teaching schedule.

Sinnott received his Harvard degrees

in 1908, 1910, and 1913. From 1908 to 1912 he was Austin teaching fellow and assistant in botany at Harvard, and for the next 2 years he served as instructor in the Harvard Forestry School.

From 1915 to 1928 he was a member of the faculty of Connecticut Agricultural College, serving as professor of botany and genetics, after which he moved to Barnard College as professor of botany. He joined the Columbia University faculty in 1939, the year before he went to Yale.

Sinnott, in addition to his long connection with the AAAS, is a member of the National Academy of Sciences, Phi Beta Kappa, Sigma Xi, American Philosophical Society, and the American Academy of Arts and Sciences. He was president in 1945 of the American Society of Naturalists, and in 1937 he was president of the Botanical Society of America. He also served on the Board of Managers of the New York Botanical Gardens from 1933 to 1940, and from 1926 to 1932 was editor-in-chief of the *American Journal of Botany*.

ALLEN O. GAMBLE has been appointed project director of the National Register of Scientific and Technical Personnel in the National Science Foundation. For the past 9 years Gamble has been with the National Advisory Committee for Aeronautics, where he directed the recruitment, examination, training, and performance-reporting programs of the NACA.

ROBERT R. WILLIAMS, chairman of the Williams-Waterman Fund for the Combat of Dietary Diseases, Research Corporation, New York, received the annual William Procter prize for scientific achievement on 29 Dec. during the AAAS meeting in Atlanta, Ga. The \$1000 award, which is administered by the Scientific Research Society of America, was presented to Williams immediately after he had delivered an address at the AAAS general session that was sponsored by RESA. He spoke on "Chemistry as a supplement to agriculture in meeting world food problems."

FREDERICK BELLINGER, chief of the chemical services division of the Engineering Experiment Station at Georgia Institute of Technology, has been selected by the United Nations to serve as an adviser to the Egyptian Government in the establishment of an industrial research program under a project arranged by UNESCO.

RUSSELL F. MILLER, former research assistant at the University of Wisconsin, has been appointed associate professor of biochemistry at Virginia Polytechnic Institute.

**HERBERT H. KENT**, former chief of the physical medicine and rehabilitation department of the Veterans Administration Hospital in Indianapolis, Ind., has been appointed associate professor of physical medicine at the University of Oklahoma School of Medicine, where he will teach in the new physical therapy school.

**LEONID A. UMANSKY**, manager of engineering for the industrial engineering department of the General Electric Co., Schenectady, N.Y., has been awarded the 1955 Edison medal, which is administered by the American Institute of Electrical Engineers. The award will be presented on 31 Jan. at a special session of the 5-day winter general meeting of the institute in the Hotel Statler, New York.

**WALTER A. MACNAIR**, vice president in charge of research of the Sandia Corporation, Albuquerque, N.M., became a vice president of Bell Telephone Laboratories on 1 Dec. He will be in charge of switching and transmission development, succeeding **GORDON N. THAYER**, who was recently named chief engineer for the American Telephone and Telegraph Company.

**WILLIAM H. HEADLEE**, professor of parasitic diseases at the Indiana University School of Medicine, has returned from Thailand where he served for 2 years as adviser to the Thai Department of Health on a program for the control of intestinal parasitic diseases. He was a member of the public health staff of the U.S. Operations Mission to Thailand (International Cooperation Administration) to which he was assigned through the Division of International Health of the U.S. Public Health Service.

**GEORGE J. WISCHNER**, director of research in the Training Methods Division of the Human Resources Research Office in Washington, D.C., has been named professor of psychology at the University of Pittsburgh, where he will expand and coordinate the graduate program in clinical psychology. In addition to his appointment as professor, he will be chairman of the clinical training committee in the college.

Wischner will head the training program for 40 to 50 graduate students in clinical psychology. This is a 4-year plan under which students serve internships with various organizations in the Pittsburgh area. They serve in Veterans Administration hospitals, the Western Penitentiary, the Pittsburgh Psychiatric Institute, the Staunton Clinic, the Pittsburgh Child Guidance Center, and in the psychology department's own clinics. In these internships, which are in addition to regular classroom and research, the

students work with patients under supervision of the clinical psychology and medical staffs of the cooperating organizations.

Other appointments in the university's psychology department include two new associate professors: **JOSEPH HERRINGTON**, former assistant chief psychologist for the Leech Farm Veterans Administration Hospital, and **JOHN REAGAN BARRY**, who for 4 years has been psychologist for the U.S. Air Force School of Aviation Medicine, Randolph Field.

**FRANCIS M. FORSTER**, dean of the Georgetown University Medical School and professor of neurology, and **FELIPE MARTINEZ**, associate professor of anatomy at Georgetown, have received the Order of Merit of Carlos Finlay from President Fulgencio Batista of Cuba. The award is made to outstanding scientists of Cuba and other countries who have contributed to the progress of Cuban science.

**PAUL D. CANTOR**, a practicing physician of Bethesda, Md., was sworn in as a member of the District of Columbia Bar at District Court on 9 Dec. Cantor attended the Georgetown University law school at night while carrying on his medical practice. He will join the Georgetown Graduate Law faculty at the beginning of the 1956 spring term, to teach a course for lawyers entitled "Medical problems of the practicing attorney." He is also a professor of legal medicine at the Georgetown University Medical School. He will continue his medical practice, as well as his consultation work in medical jurisprudence.

**DOROTHY M. SMITH**, assistant director in nursing at Hartford (Conn.) Hospital School of Nursing, has been appointed dean of the College of Nursing at the University of Florida. She will join the staff at the J. Hillis Miller Health Center on 1 Feb. 1956.

**NANDOR FORGES** of the U.S. Department of Agriculture's Eastern Regional Research Laboratory, Philadelphia, Pa., has been named supervisory chemist of the Dairy Waste Unit. This unit recently received the USDA award for superior service "for research which led to the development of inexpensive plants for the treatment of milk processing wastes to prevent stream pollution." The research team included **SAM R. HOOVER** and **LENORE JASEWICZ** who had worked together for a number of years on this problem.

**ANDREW ROBESON**, formerly of Emory University, has been appointed associate professor of physics at Virginia Polytechnic Institute.

**ALTON MEISTER** has been appointed professor and chairman of the department of biochemistry at Tufts University School of Medicine, effective 1 Jan. He has been head of the clinical biochemical research section of the National Cancer Institute, National Institutes of Health, since 1951, and has been at NIH since 1946.

**ODOM FANNING** has been appointed to the new position of manager of information services at Midwest Research Institute. For the past 2 years he has been in charge of the publications services of the Georgia Institute of Technology Engineering Experiment Station and editor of the station's magazine, the *Research Engineer*.

**RAYMOND STEVENS**, senior vice president of Arthur D. Little, Inc., consultants and engineers of Cambridge, Mass., has been chosen to receive the 1956 gold medal of the American Institute of Chemists. He is being honored for his "contributions to the wider understanding of essential procedures for the management and operation of industrial research." The medal will be presented during the annual meeting of the institute, 9-11 May, at the Hotel Statler, Boston, Mass.

**GEORGE EDWARD SHORT**, after 4 years of veterinary practice, has joined the veterinary division of the Norwich Pharmacal Company, Norwich, N.Y.

■ The following appointments to assistant professor have been announced. University of Oklahoma: **EARL O. LARSEN**, biochemistry. Michigan State University: **DUANE E. ULLREY**, animal husbandry. Massachusetts Institute of Technology: **RICHARD R. DOELL**, seismology and geomagnetism; **JOHN W. WINCHESTER**, nuclear geochemistry. Medical College of Georgia: **JOHN R. FAIR**, surgery and ophthalmology. Albany Medical College: **JOSEPH HARRIS** and **ARTHUR WEISSBACH**, biochemistry. Cornell University: **DAVID W. BIERHORST** and **CONRAD S. YOCUM**, botany. Virginia Polytechnic Institute: **WILLARD OSBORNE ASH**, statistics.

#### Necrology

**HOWARD S. BRODE**, Santa Monica, Calif.; 89; professor emeritus of biology and curator of the museum at Whitman College; emeritus life member of the AAAS; father of Robert B. Brode, president of the AAAS Pacific Division, and Wallace R. Brode, a member of the AAAS editorial board and board of directors; 11 Dec.

**REV. JOSEPH F. CARROLL**, Milwaukee, Wis.; 63; former head of the physics de-

partment at Marquette University; authority on earthquakes; 12 Dec.

MARTIN GIL, Buenos Aires, Argentina; 86; astronomer; 9 Dec.

HORACE P. LIVERSIDGE, Bryn Mawr, Pa.; 77; electrical engineer; 9 Dec.

EGAS MONIZ, Lisbon, Portugal; 81; developer of cerebral angiography and pre-frontal leucotomy; 1949 winner of the Nobel prize for medicine for having been the first man to cure a mental disorder by surgical operation; professor of neurology at the University of Lisbon from 1911-44; 13 Dec.

WOLFGANG PAULI, Zurich, Switzerland; 85; colloid chemist; professor emeritus, University of Vienna, Vienna, Austria; 4 Nov.

ROBERT E. SHELBY, Teaneck, N.J.; 49; vice-president and chief engineer of the National Broadcasting Company, New York; pioneer in the development of television; 9 Dec.

HERMANN WEYL, Zurich, Switzerland; 70; mathematician; one of the founders of the Institute for Advanced Study, Princeton, N.J. and professor emeritus since his retirement in 1951; author of many books, he was also recognized as an eminent historian in the philosophy of science; 8 Dec.

## Education

The Atomic Energy Commission and the National Science Foundation have announced joint sponsorship with the American Society of Engineering Education of a special Summer Institute on Nuclear Engineering for engineering college faculty members. The AEC has approved use of the Argonne Laboratory School of Nuclear Science and Engineering for the institute, which will continue for 2 months beginning the latter part of June. Courses will be given in nuclear physics, nuclear engineering, metallurgy, instrumentation and other subjects. Sixty students will be enrolled.

NSF has approved establishment of a fund to provide cost-of-living stipends of about \$600 to those attending the institute and to defray their travel expenses. These funds will be administered by Northwestern University. The American Society for Engineering Education will arrange for the selection of the students and make the necessary housing arrangements.

Purpose of the institute is to broaden the nation's educational base in atomic energy by equipping more college faculty members to teach students of nuclear sciences. In addition to the need for more fundamental-research scientists in nuclear energy, the AEC estimates that the developing American civilian atomic energy industry will create an annual demand for nearly 2000 trained nuclear

scientists and engineers during the next 3 years and that the demand after that period will be even greater.

It will be the policy of the institute to accept from a single university or college two to four faculty members representing various engineering fields. This policy will permit spreading nuclear technology into the existing disciplines and make possible a better integrated program of nuclear training in the schools. No tuition will be charged. Inquiries concerning enrollment may be addressed to the Dean of Engineering, Northwestern University, Evanston, Ill. Applications must be submitted by 1 Mar.

The University of Wisconsin will build an \$800,000 addition to Sterling Hall on the Madison campus to house the Mathematics Research Center of the U.S. Army. The general objective of the center is to ". . . provide a nucleus of highly qualified mathematicians who will carry on investigations in mathematics of interest to the Army and who can be called upon for advice on specific problems beyond the capability of Army facilities. In addition to fulfilling an Army need, the center will aid the national effort in mathematics research and will increase the availability of trained mathematicians."

R. E. Langer, professor of mathematics, will be the first director of the center. Investigations to be carried on at the center will be primarily concerned with four general fields: mathematical analysis and applied mathematics; statistics and probability; numerical analysis and the technology of high-speed electronic computing machines; and operations research, decision theory, optimization problems, and programming.

Sets of 156 drawings to enable schools in tropical countries to build low-cost science teaching laboratories have just been issued by UNESCO. The drawings cover equipment needed in primary and secondary science teaching and in the training of science teachers. They are intended to be particularly useful to countries that are short of science teaching equipment and lack foreign exchange to import apparatus, yet which have crafts-men and vocational schools where the equipment might be manufactured locally at low cost.

The 23rd session of the Norelco X-ray Diffraction School will be held at the North American Philips Company, Inc., 750 South Fulton Ave., Mount Vernon, N.Y., during the week of 30 Jan.-3 Feb. Registration will be limited to 125 for the first 4 days and to 150 on Friday, the day devoted to actual application problems when guest speakers discuss

methods currently in use by researchers and industrial plants.

On Monday through Thursday, the sessions will be devoted to extensive classroom and laboratory work during which participants discuss their own problems and become familiar with the use of the various types of equipment. The basic subjects to be considered include x-ray diffraction, diffractometry, and spectrography. There will also be discussion of new high- and low-temperature camera techniques, electron microscopy, and electron diffraction.

Application for attendance at the three Norelco X-ray Diffraction Schools held last year far outnumbered the available accommodations. It is recommended that those planning to participate in the coming meetings make their reservations at the earliest possible date. There is no registration fee.

## Grants, Fellowships, and Awards

The American Therapeutic Society has announced its annual Oscar B. Hunter memorial award contest. The award is made in recognition of an outstanding contribution or series of contributions to therapy by an individual or a team of workers. The term *therapy* is used in a broad sense to include the use of any drugs, procedure, or device of benefit in the treatment of patients.

One object in making the award is to bring recognition to those who have not received awards for their work. The award consists of a bronze medal engraved with the name of the recipient. The winner will be expected to deliver a paper when the award is presented at the society's annual meeting; this paper must cover the work that forms the basis for the honor. Travel expenses to the meeting will be furnished.

The deadline for receiving nominations is 1 Feb. 1956. For information write to the chairman of the award committee, Harry E. Ungerleider, 393 Seventh Ave., New York 1.

Grants from the Permanent Science Fund of the American Academy of Arts and Sciences are made in support of research in any field of science whatsoever in amounts that ordinarily do not exceed \$1500. Applications for grants to be made next March should be filed by 1 Feb. on forms available from the Chairman, Permanent Science Fund Committee, American Academy of Arts and Sciences, 77 Massachusetts Ave., Cambridge 39, Mass.

Special consideration will be given to projects on new frontiers of science, those that lie between or include two or more of the classical fields and those proposed by investigators who may be on

the threshold of investigational careers or who are handicapped by inadequate resources and facilities. The committee does not ordinarily approve grants for research the results of which constitute partial fulfillment of requirements for an academic degree.

■ The Explorers Club has adopted a new rule under which grants from the Exploration Fund may be given to scientists who are not members of the club. Application blanks may be obtained by writing to the Explorers Club, 10 W. 72 St., New York 23.

■ The department of biochemistry, University of Washington, announces the availability of teaching and research assistantships for the academic year 1956-57. These assistantships carry a stipend of \$150 per month and remission of tuition and laboratory fees.

In addition, a number of research assistantships are offered for the summer months. Applicants having a bachelor's degree in chemistry, or its equivalent, are invited to apply before 15 Mar. by writing to the executive officer, Dr. Hans Neurath, Department of Biochemistry, University of Washington, Seattle 5.

## In the Laboratories

■ Vitro Laboratories, a division of Vitro Corporation of America, plans to build a \$1-million laboratory near Silver Spring, Md. The new laboratory will replace the present leased facilities of the Silver Spring Laboratory of the division, and will allow for greatly increased expansion and many improvements. Vitro has purchased 35 acres in Montgomery County, 7 miles north of the present laboratory. Ground will be broken early next year and the first building will be ready for occupancy by 1957.

The initial laboratory structure calls for 55,000 square feet of usable floor space, suitable for 350 persons, as well as storage and other auxiliary features. The design will permit an early expansion to 100,000 square feet of floor space.

The Silver Spring Laboratory carries out research, development, and engineering contracts for both Government and industry, chiefly for the Navy and largely in the field of weapons systems, including underwater ordnance and guided missiles.

■ The entry of Raytheon Manufacturing Company, Waltham, Mass., into the atomic energy field was announced on 8 Dec. with the publication of its pamphlet, *Nuclear Reactor Data*. The booklet lists all significant data on every nuclear reactor that is known to be already built or under construction any-

where in the world, including six in the Soviet Union.

The study that resulted in the booklet was carried out under the direction of William A. Robba, head of the firm's nuclear power group in the research division. Material was gathered from a wide variety of sources, including scientific journals and other published works in many languages. The entire project was aided greatly by the declassification of significant quantities of information for the Geneva Conference.

A feature of the pamphlet is a comprehensive chart listing all reactors built since Enrico Fermi constructed the first one in Chicago 13 years ago, and including those that are partially constructed or definitely planned and engineered for future construction. Facts and figures were checked against two or more sources wherever possible. The chart shows up to 50 principal characteristics of each of the nearly 100 reactors listed. These characteristics include the function, builder, location, and important technical features of the reactors.

■ A new chemical plant will be constructed by the Glidden Company at Port St. Joe, Fla., to utilize the crude skimmings created as a by-product by the St. Joe Paper Company and other southern kraft paper mills. The new unit will produce crude and distilled tall oil, high grade fatty acids, premium-grade tall oil rosins, and by-product pitch. The Port St. Joe facility will be the fourth chemical plant to be operated by Glidden in the South.

## Miscellaneous

■ Installation of a Foucault pendulum is now nearing completion in the main lobby of the General Assembly Building at United Nations Headquarters in New York. The pendulum, a gift to the U.N. from the Government of the Netherlands, utilizes the principle first demonstrated by the French physicist, Jean Bernard Leon Foucault, in Paris in 1851, when he suspended a heavy sphere from the dome of the Pantheon by a 220-foot wire. A pin was attached to the underside of the large ball, and at each swing the pin swept over a ridge of sand arranged on an inner railing inside a spectators' circular railing. At each swing the pin cut into the sand pile. It was almost immediately observed that the plane of vibration shifted slowly in a clockwise direction, the rate of deviation being some 11 degrees an hour. Actually the floor was turning around under the pendulum because of the earth's daily rotation.

For the U.N. installation, a 200-pound gold-plated sphere is being suspended

from the ceiling 75 feet above the floor of the Assembly lobby, and directly above a stair landing connecting the lobby with the main entrance to the General Assembly hall. A stainless steel wire will hold the sphere in such a manner as to allow the weighted ball to swing freely in any plane.

The sphere, 12 inches in diameter, will swing directly over a raised metal ring, some 6 feet in diameter and containing an electromagnet in the center. When activated, the electromagnet will cause an impulse in the ball sufficient to overcome the resistance of the air and friction at the suspension above. The sphere will thus swing continuously as a pendulum, its plane shifting slowly in a clockwise direction, as it did in Foucault's original experiment.

Installation of the pendulum is under the supervision of William Bahler, a physicist of the Phillips Company, Eindhoven, Netherlands. Inscribed on the shaft supporting the electromagnetic ring is the following message: "It is a privilege to live this day and tomorrow. Juliana."

■ The U.S. Information Agency's pamphlet *Atomic Power for Peace* has been printed in 35 languages for a total of almost 6½ million copies since May 1954.

■ The *Engineering Societies Directory*, a complete list of all engineering societies in the United States, together with pertinent information about them, will be published by the Engineers Joint Council. The tentative release date is 1 June 1956. The *Directory* will be a new publication, not a revision of the *Engineering Societies Yearbook*, which has been discontinued.

Questionnaires will be mailed to all known societies about 16 Jan. and should be returned to EJC by 1 Mar. If a society has not received such a questionnaire, it should write the Engineers Joint Council, 29 W. 39 St., New York.

■ The University of Western Australia is establishing a medical school and invites applications for the chairs of anatomy, biochemistry, medicine, microbiology, pathology, physiology, obstetrics and gynecology, and surgery. Closing date for receipt of applications is 31 Jan.

■ A competitive examination for appointment of medical and dental officers to the regular corps of the U.S. Public Health Service will be held on 20, 21, and 22 Mar. at various places throughout the United States. A candidate will be tested at the examining center nearest his home. Applications must be received in the Public Health Service, Washington 25, D.C., no later than 10 Feb.

## Reports and Letters

### Determination of Magnesium in an Insect Virus

A semiquantitative emission spectrographic analysis (1) of *Bombyx mori* L. (silkworm) polyhedral bodies and of virus revealed iron and magnesium as the only metals present in appreciable quantities. A note on the iron content has been published (2). The quantitative determination of magnesium presented great difficulties, owing to the low magnesium concentration and the small quantities of virus available. The low concentration excluded the emission spectrographic method, because, with the available electrodes, it was not possible to burn several milligrams of protein and obtain reproducible results. Practically all the numerous colorimetric methods described in the literature, which are very well summarized by Mitchell (3), as well as several combinations of them, were tried. Combustion of the organic matter presented the greatest problem. Dry ashing in quartz tubes at temperatures ranging from 400° to 600°C did not yield reproducible results because of the formation of insoluble oxides and/or volatile products. Effective wet ashing requires high concentrations of acids, which results in high salt concentrations that interfere seriously with most colorimetric determinations. Nitric or hydro-

chloric acids, which can be evaporated after ashing, are unsuitable because of heavy losses during evaporation.

However, the titan yellow method as described by Orange and Rhein (4) combined with that of Young and Gill (5) using ghatti gum as color stabilizer is useful for the determination of small quantities of magnesium in proteins. Yet this method is unsuitable for virus samples because of interference by nucleic acid and other materials present. Intensive investigations trying numerous combinations (6) resulted finally in a greatly simplified yet sensitive procedure that is particularly useful for determination of magnesium in comparatively pure nucleoproteins and viruses. It is based on the well-known thiazole yellow method, follows partly the procedure of Young and Gill (5), and uses glycerol as color stabilizer as recommended by Hanssen *et al.* (7). The use of "compensating solutions" against interfering ions was found to be unnecessary since the samples were comparatively pure. Various other "color stabilizers" increased the blank readings and were found to be unreliable and unnecessary for quantities up to about 10 µg of magnesium when glycerol was used.

Samples up to 10 mg, dry or in solution, were placed in quartz digestion tubes, and 0.25 ml of concentrated H<sub>2</sub>SO<sub>4</sub> was added to each. Blanks and standards were prepared similarly and all samples were dried for about 8 hr at 150°C in a drying oven. They were then ashed at 210°C (silicone bath) for 8 hr; 1 drop of H<sub>2</sub>O<sub>2</sub> (30-percent) was added every hour except the last. After cooling, 3.25 ml of distilled water and 1.5 ml of glycerol-water (1:1) were added, and the samples were well mixed. Next 0.15 ml of 0.02-percent thiazole yellow (8), prepared freshly daily was added; immediately after, 1.0 ml of 10N NaOH (carbonate-free) was added; and the two were well mixed. The samples were allowed to stand for 25 minutes and were then read in a spectrophotometer at a wavelength of 510 mµ and a light path of 5 cm. With the Beckman instrument, the blanks had an optical density of 0.450, and the standards had an optical density of approximately 0.050 per microgram of magnesium. A standard solution con-

taining 5 µg of magnesium per milliliter was prepared by dissolving 51.25 mg of MgSO<sub>4</sub> · 7H<sub>2</sub>O in 1 lit. It is most important that all glass and quartz ware be carefully cleaned with chromic acid and well rinsed. Although reproducibility of the method is about ± 5 percent, it is advisable to run standards with the samples.

The polyhedral bodies, polyhedral proteins, and polyhedral virus were purified and prepared as described previously (9). The polyhedral protein was dialyzed against a total of 40 lit of distilled water with four changes for several days in the cold room, and the virus was washed four times by high-speed centrifugation. The results of the magnesium determination summarized in Table I show that *B. mori* polyhedral bodies contain about 0.083 percent magnesium and that the virus contains about 0.033 percent magnesium. Ten samples of purified polyhedral protein weighing between 3 and 9 mg each yielded no magnesium. This indicates that practically all the magnesium found in the polyhedral bodies is either adsorbed or loosely bound by a salt linkage that is split during the dissolution of the polyhedral bodies by weak alkali (0.006M Na<sub>2</sub>CO<sub>3</sub>). The latter possibility is more likely, since a major part of the phosphorus present in the polyhedral bodies is also loosely bound and dialyzable. It is possible that the magnesium and phosphorus are essential for crystallization of the polyhedral protein.

It is impossible to dialyze the virus particles effectively without destroying their structure and infectivity. However, four washings with 20 ml of distilled water would be expected to remove most of the magnesium adsorbed on the virus surface. It is felt, therefore, that the magnesium found is a normal constituent of the virus. From the amount of magnesium and a virus particle weight of  $45.6 \times 10^{-17}$  g, one can calculate that each virus particle contains about 3.00 atoms of magnesium, which could be of biochemical significance.

C. F. HOLOWAY\*

Department of Chemistry, Michigan  
College of Mining and Technology,  
Sault Ste. Marie

G. H. BERGOLD

Laboratory of Insect Pathology,  
Sault Ste. Marie, Ontario

#### References and Notes

- Contribution No. 235 of the Forest Biology Division, Science Service, Department of Agriculture, Ottawa, Ont. We wish to express our appreciation to J. MacNamara and E. Herbert of the Algoma Steel Corporation, Ltd., Sault Ste. Marie, Ont., for the spectrographic results. We also wish to thank Lorna Callahan for her technical assistance.
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- Present address: George Williams College, Drexel at 53 St., Chicago, Ill.

29 July 1955

### Induction of Flowering in Pineapple by Beta-Hydroxyethylhydrazine

Some years ago, Rodriguez demonstrated that ethylene could induce pineapple plants to flower (1). Subsequently, it was found that acetylene could also "force" differentiation of flower buds in the pineapple plant (2). With these exceptions, the chemical materials reported to induce flowering in the pineapple have had the chemical structure characteristic of plant growth regulators and have given positive results in the various tests for such properties (stimulation of cell elongation, initiation of roots, and so forth). Such flower-inducing materials as 2,4-dichlorophenoxyacetic acid, 1-naphthaleneacetic acid, and 2-naphthoxyacetic acid have a ring system nucleus, a double bond in the ring, a side chain containing a carboxyl group (or structure readily converted to it), and, presumably, the necessary spatial relationship between the ring and the carboxyl group (3). They are also active in the Went split-pea-stem test (4).

Beta-hydroxyethylhydrazine,  $\text{H}_2\text{NN}-\text{HCH}_2\text{CH}_2\text{OH}$ , gave no activity in the split-pea-stem test or in the *Avena* test and has none of the structures associated with plant-growth-regulator activity. However, it has induced early flowering

in two tests at different seasons in the pineapple, *Ananas comosus*, variety smooth Cayenne (5). The chemical was applied in water by sprinkling can to 20 plants at each treatment rate in each test. Plants of test 1 were planted in May 1953; they were treated 18 May 1954, and the buds were counted 23 July 1954. Plants of test 2 were planted in October 1953; they were treated 15 September 1954, and the buds were counted 15 November 1954 (Table 1).

It would be of interest to determine the effect of this chemical on long- or short-day plants undergoing inductive periods to ascertain whether it has the properties of an auxin antagonist.

DONALD P. GOWING  
ROBERT W. LEEPER

Pineapple Research Institute  
of Hawaii, Honolulu

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- We wish to express our appreciation to the Olin Mathieson Chemical Corporation for providing the beta-hydroxyethylhydrazine and to Martha J. Kent for the split-pea-stem and *Avena* assays. This report is published with the approval of the director of the Pineapple Research Institute of Hawaii as technical paper No. 236.

26 July 1955

### Effect of Stress on an Extinguished Fear Response

Gellhorn (1) has reported a series of studies that were made to determine whether convulsions induced by Metrazol, electroshock, or insulin hypoglycemia would effect the acquisition and/or extinction of a simple conditioned avoidance response. By means of a two-compartment box, a barrier, and shock, rats were taught jumping response that enabled them to escape shock in one of the compartments. A bell was generally used as the conditioning stimulus, although in some cases a light was used. A number of Gellhorn's findings are pertinent to the present study. Gellhorn found that a conditioned avoidance response, extinguished by lack of reinforcement, could be reinstated following three to five convulsions that were induced by electroshock or Metrazol. Reinforcement lasted 5 to 10 days, after which a gradual decrease in the frequency of the response occurred. Gellhorn reported that with the use of insulin, only in the case of production of a coma state was the extinguished avoidance response reinstated. In this case, the recovered response lasted as long as several months without reinforcement. Evidence was presented that

was interpreted as indicating that the coma state was the essential condition for reinstatement of the avoidance response.

The present study (2) reports the effect of stress induced by treadmill running on an extinguished conditioned fear response.

A modified Miller box (3) was used for the acquisition of a conditioned fear response. This apparatus consisted of a rectangular box, the over-all dimensions of which were 28 by 7½ by 11½ inches, that was divided into two equal chambers by a partition containing a manually operated vertical sliding door. One compartment, painted white, contained a charged grid floor and a lead weight that was suspended by a wire to the left of the intercompartment door. One compartment was painted black; it contained no suspended weight and its grid floor was uncharged.

By means of standard conditioning procedure, ten male inbred albino rats were taught to escape shock in the white compartment by hitting the suspended weight with their forepaws. On performance of this act, the experimenter opened the sliding door and allowed the subject to escape to the black compartment. All animals were conditioned to hit the weight and escape to the black compartment immediately on placement in the white compartment, in the absence of shock.

After this habit had been acquired, the response was extinguished by lack of reinforcement. The subjects were then exposed to treadmill (4) running, with noninjurious shock as a motivator, for a 5-minute period daily for 1 week. Subsequently, the animals were replaced in the conditioning apparatus. Ten matched male albino rats used as controls were not subjected to the treadmill running.

We have previously reported (5) that some rats that were subjected to treadmill running became so highly agitated that they exhibited full pattern convulsions, including tonic, clonic, and coma stages. In the present study, four of the ten experimental animals showed complete pattern fits on each exposure to the treadmill. The remaining six rats, although they were agitated, did not show seizures. It was found that after exposure to the treadmill running the extinguished fear response was reinstated in all experimental subjects. After a period of 1 week, the fear response of the six animals not showing the convulsions gradually disappeared; the fear response was not evidenced in any of these subjects 14 days following the treadmill experience. In the case of animals showing full pattern fits, the reinstated fear response continued to be manifested with regularity, and in the absence of reinforcement, for a period of 3 weeks following treadmill experience.

Table 1. Induction of flowering in the pineapple with beta-hydroxyethylhydrazine.

Material	Concn. (%)	Plants with flower buds (No.)
<i>Test 1</i>		
Beta-hydroxy-ethylhydrazine	0.001	0
	0.01	0
	0.06	18
	0.12	20
Untreated control		1
<i>Test 2</i>		
Beta-hydroxy-ethylhydrazine	0.01	0
	0.06	1
	0.12	13
	0.23	18
Untreated control		0

None of the controls showed spontaneous recovery of the extinguished habit during the 3-week period in which the experiments evidenced reinstatement.

Despite the fact that the nature of the habit acquired by our subjects and the method used to induce the seizures differed from Gellhorn's, it seems apparent that convulsive states that include coma are most effective in the reinstatement of a conditioned fear response. However, in the case of reinstatement of the response used in this study, it seems that excitement produced by treadmill running does at least have a transient effect.

WILLIAM J. GRIFFITHS, JR.  
Department of Psychology, University of Mississippi, University

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22 July 1955

### Relationship of Nitrogen Content of Hyaluronic Acid Preparations to Hyaluronidase Activity

Eighteen samples of hyaluronic acid were prepared (1) from various tissues by the methods of Harris and Harris (2), Tolksdorf *et al.* (3), Meyer (4), and Dorfman and Ott (5). Tissues employed were human umbilical cords, spleens, carcinomatous uteri, a portion of greater omentum invaded by carcinoma, a carcinomatous breast, pooled CBA mouse mammary tumors, pooled rat tumors (Walker 256), and pooled vitreous humor from beef eyes. Variations in the products from the same and different tissues are apparent in Table 1.

Turbidity was determined in the Coleman photonephelometer (Model 7) by a technique modified from that of Kass and Seastone (6). Aliquots (0.2 mg in 0.1 ml) of each of the hyaluronic acid preparations were placed in separate Wassermann tubes (13 by 100 mm). To each of these tubes was added 0.1 ml of acetate-buffered sodium chloride. After mixing, the tubes were incubated at 37°C for 15 minutes. Acidified albumin (7.0 ml) was added to each of the tubes, which were then incubated at room temperature for 20 minutes. The contents of each tube were poured into a cuvette and read in the photonephelometer adjusted to maximum sensitivity. To a second series of tubes containing the different

substrates was added 0.1 ml of buffer solution containing 5 turbidity-reducing units of bull testis enzyme (Wyeth). This set of tubes was treated in the same manner as the controls. The effect of the given concentration of hyaluronidase on each of the hyaluronic acid preparations was determined by subsequent decrease in turbidity.

The percentage of nitrogen (duplicate samples of 1.0 mg) of the hyaluronic acid preparations was determined by the micro-Kjeldahl method as described by Kabat and Meyer (7).

Turbidities varied with different hyaluronic acid-hyaluronidase mixtures. A direct relationship was noted between the percentage of nitrogen of the hyaluronic acid preparations and the degree of activity of bull testis enzyme on the substrate. An enzyme activity ratio (EA ratio) was obtained for each substrate by dividing (i) the photonephelometer reading given by 0.2 of hyaluronic acid by (ii) the photonephelometer reading given by

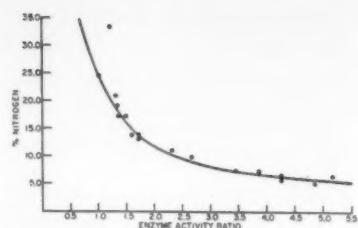


Fig. 1. Relationship of enzyme activity ratio of hyaluronic acid substrates to their nitrogen content.

0.2 mg of hyaluronic acid after it had been acted on by 5 turbidity reducing units of bull testis enzyme for 15 minutes.

Table 1 lists the laboratory number, tissue source of substrate, yield, EA ratio, and nitrogen content for each of the preparations. Hyaluronic acid preparations presenting low EA ratios are associated with high percentages of nitrogen and, inversely, those preparations yield-

Table 1. Hyaluronic acid preparations. Italic numbers in parentheses in column 1 refer to literature that describes the method of preparation.

Preparation	Tissue		Yield (g)	Galvanometer readings 0.2 mg substrate		EA ratio	Content (%N/mg)
	Source	Wt. (g)		No enzyme	5 TRU		
1 (2)	Human umbilical cord	100*	1.7	135	51	2.65	9.8
2 (3, 5)	Human umbilical cord	50*	18.0	34	8	4.25	6.5
3 (3, 5)	Human umbilical cord	2†	0.84	31	6	5.15	6.5
4 (3, 5)	Human umbilical cord	100*	4.75	92	19	4.85	5.1
5 (3, 5)	Cow carcinoma‡	89 → 4.5 → 0.05	135	101	1.33	19.1	
6 (3, 5)	Cow carcinoma‡	89 → 5.0 → 0.28	81	19	4.25	5.9	
7 (3, 5)	Human spleen (normal)	24* → 2.7 → 0.16	6	5	1.2	33.3	
8 (3, 5)	5 human spleens	99* → 1.3 → 0.07	149	147	1.0	24.5	
9 (3, 5)	Pooled rat tumors (Walker)	25*	2.0	111	87	1.3	20.8
10 (3, 5)	¶	0.5	0.037	116	85	1.36	17.1
11 (3, 5)	¶	0.5	0.033	90	61	1.47	17.1
12 (3, 5)	Human uterine adenocarcinoma	32* → 4.0 → 0.5	44	28	1.57	13.8	
13 (3, 5)	Human uterine adenocarcinoma	20* → 5.6 → 0.5	60	4	15.0	14.1	
14 (3, 5)	Human umbilical cord	90*	5.4	112	29	3.87	7.3
15 (3)	Human mammary adenocarcinoma	177	0.3	24	7	3.43	7.5
16 (3)	Human omental adenocarcinoma	398	3.8	36	21	1.71	13.2
17 (3)	CBA mouse mammary tumors (pooled)	46	0.34	27	16	1.7	13.8
18 (4)	Beef eye vitreous humor (pooled)	370	0.1	32	14	2.3	11.0

\* Dry weight. † A portion of preparation 2 was reprocessed. ‡ Hereford cow squamous cell carcinoma collected by Frank X. Gassner of Colorado A & M College, Fort Collins. About 500 g (wet weight) yielded 89 g of substrate, which was reprocessed in two portions (preparations 5 and 6). || Preparation 9 was reprocessed in two 0.5-g amounts. Results recorded as preparations 10 and 11. || Wet weight.

ing high EA ratios are associated with low percentages of nitrogen (except preparation 13). The index of each of the hyaluronic acid preparations was plotted on arithmetic graph paper as the ordinate (Fig. 1). Laboratory preparations 7 and 13 provided the maximum deviations from the curve. Preparation 13 gave an unusually low turbidity reading after having been acted on by 5 turbidity reducing units of bull testis enzyme. It is doubtful whether preparation 7 actually was a hyaluronate. Certain actions of hyaluronidases of varying origin on these substrates will be reported at length.

ROGER B. FUSON\*

STANLEY MARCUS

*Department of Bacteriology, University of Utah College of Medicine, Salt Lake City*

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### Foot-and-Mouth Disease Virus: Its Growth and Cytopathogenicity in Tissue Culture

We wish to report that foot-and-mouth virus (FMV) reproduces and causes cytopathogenic changes in both swine and bovine kidney tissue cultures. Practical techniques have been developed for the assay of the virus and its antibodies as well as for the production of virus on a relatively large scale.

Swine or bovine kidney from young animals was cut into pieces weighing approximately 0.5 g and placed in phosphate buffer solution at pH 7.3 containing penicillin and streptomycin. The tissue was washed repeatedly in fresh changes of buffer solution and then stirred gently in a 0.25-percent trypsin buffer solution. The liberated cells were decanted at 10-minute intervals through cheesecloth, centrifuged at low speed, washed twice, and diluted 1 to 200 with culture medium. The medium consisted of Hanks' salt solution containing 2.0 percent bovine serum, 0.5 percent lactalbumin hydrolyzate, penicillin, and streptomycin. Culture tubes (16 mm in diameter by 150 mm) and Roux flasks were seeded with the cellular suspensions and incu-

Table 1. Cytopathogenicity and growth of foot-and-mouth disease virus type A in tissue culture.

No.	Method†	Passage		Tissue culture ID <sub>50</sub> /ml		Generalized FMV disease in
		Total dilution* (neg. log)	TP expt. in swine kidney (log)	Titration in bovine kidney (log)		
1	CP	2.0				
2	CP	3.0				
3	CP	4.0				
4	TP	5.0	5.80			
5	TP	9.0	5.98	6.80		Guinea pigs
6	TP	13.0	5.68	5.68		
7	TP	16.0	‡	5.98		
8	TP	19.0	4.80			
9	TP	21.0	6.15			
10	TP	25.0	5.93			
11	TP	29.0	5.68			
12	TP	31.0	5.98	5.47		
13	TP	39.0	5.80			
14	TP	35.0	6.13			

\* Effective dilution of original mouse infectious tissue (neg. log). † CP, conventional passage method; TP, titration-passage technique. ‡ Culture acidity interfered with reading.

bated stationary at 37°C. The swine and bovine cultures developed confluent outgrowths of mixed epithelial and fibroblastic cells within 3 and 6 days, respectively.

Foot-and-mouth virus type A was passed 14 consecutive times in swine cultures (Table 1). The first four passages were made by conventional methods. The virus inoculum for the first passage was of bovine origin and was passed once in suckling mice just prior to its use (1). When it was inoculated into cultures, cytopathogenic changes were produced that were similar to those reported for cultures infected with vesicular exanthema and vesicular stomatitis viruses (2, 3). Isolated plaques of pyknotic cells were formed in less than 15 hours. Passages 5 to 14 were made by a titration-passage technique, which had been used previously with vesicular stomatitis virus, in which each passage is made as a complete titration (3).

Five cultures were inoculated with each dilution passed. After 20 hours' incubation, the cultures were examined microscopically. The pooled fluid from the highest dilution in which all cultures exhibited extensive cytopathogenic damage was serially diluted and used as inocula for the next titration passage. In most instances, this procedure effected a 10<sup>-3</sup> or 10<sup>-4</sup> interpassage dilution of the cytopathogenic agent (Table 1, column 3). The inocula used for serial passages 5 to 7 and 12 in swine cultures were also assayed in bovine cultures. Table 1 shows that titration-passage inocula usually contained about 10<sup>6.0</sup> ID<sub>50</sub> per milliliter for both kinds of cultures. After a few passages in swine cultures, it was evident that infectivity of the original virus in-

oculum had been diluted out and that the cytopathogenicity that persisted was probably owing to the propagation of FMV.

This presumption was confirmed by animal inoculations and serum neutralization tests. Passage fluid No. 5 (10<sup>-9</sup> dilution of the original mouse tissue) was inoculated intradermally into the foot pads of guinea pigs. Passage fluid No. 13 was inoculated intradermally into a Hereford steer. Both animal species developed extensive local and generalized lesions of foot-and-mouth disease.

In the neutralization tests, the capacities of normal guinea pig serum and of two antiserum samples (1) to neutralize the infectious culture fluid from passage No. 5 were determined. The antisera used were from guinea pigs that had been hyperimmunized to vesicular stomatitis virus (New Jersey type) and to FMV (type A). Tenfold serial dilutions of the infectious fluid were made and aliquots of each were mixed in equal parts with a 1 to 5 dilution of each serum type. The virus and virus-serum mixtures were incubated for 1 hour at 37°C and then assayed in bovine kidney cultures. The virus fluid alone was found to contain 10<sup>5.83</sup> tissue culture ID<sub>50</sub> per 0.2 ml, but in the presence of the type A antiserum, it retained less than 10 such units of infectivity. The normal and heterologous serums had no detectable neutralizing activity.

It is estimated that the kidneys from one calf will supply enough cells to prepare 50,000 cultures in tubes or more than 300 in Roux flasks. The cultures in tubes are now being used regularly for assays of virus taken directly from in-

fected bovine tongue tissue. The Roux flask cultures are used for the production of FMV on a relatively large scale. Each flask yields 75.0 ml of fluid containing approximately  $10^{7.0}$  tissue culture ID<sub>50</sub> per milliliter.

H. L. BACHRACH  
W. R. HESS  
J. J. CALLIS

*Plum Island Animal Disease Laboratory,  
U.S. Department of Agriculture,  
Greenport, New York*

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### Ability of Sodium Sulfate to Stimulate Growth of the Chicken

Reports demonstrating that only a trace of Na<sub>2</sub>S<sup>35</sup>O<sub>4</sub> is incorporated into sulfur amino acids (1, 2), that larger fractions are incorporated into taurine (1, 3-5), but that the largest uptake of radiosulfate occurs in the chondroitin sulfate matrix of cartilage (2, 3) led us to study the nutritional significance of these findings (6).

Chickens were fed rations containing casein, 15 percent; gelatin, 10 percent; corn oil, 4 percent; salts "A" (7), 6 percent; all essential vitamins in excess of their requirements (8); and glucose to make 100 percent. The protein furnished about 0.08 percent cystine and 0.51 percent methionine.

Sulfur or Na<sub>2</sub>SO<sub>4</sub> added to this diet did not improve growth; however, when the sulfates of magnesium, manganese, and copper present in salts "A" were replaced with equimolar levels of the corresponding oxides or chlorides (new basal diet: LC2MS), it was found that sodium sulfate improved growth and feed efficiency. Typical data are given in Table 1. Dietary sulfate, in addition, appears to be capable of stimulating normal feather development, even though the sulfur amino acid content was too low to support optimal growth.

Feathers from birds that received Na<sub>2</sub>S<sup>35</sup>O<sub>4</sub> for 10 to 14 days in amounts sufficient to maintain blood levels of 0.01  $\mu\text{c}/\text{ml}$  of plasma were quite radioactive (0.5 to 1.0 percent of the total isotope dose), but feather cystine and methionine accounted for less than 5 percent of this activity. Sulfate isolated after feather hydrolysis accounted for 60 percent, and about 30 percent was contributed by a nonsulfur amino acid, nonsulfate fraction that is still unidentified. This unidentified fraction also accounted for about 30 per-

cent of the total feather activity when methionine-S<sup>35</sup> was fed in a similar fashion even though the sulfate fraction then accounted for less than 5 to 10 percent.

Sulfur amino acids isolated from hydrolysates of other tissues from birds that had received Na<sub>2</sub>S<sup>35</sup>O<sub>4</sub> for the period of 10 to 14 days incorporated only small amounts of S<sup>35</sup>. We feel that the low levels of activity found in tissue sulfur amino acids merely reflect bacterial synthesis in the alimentary tract.

Taurine accounted for approximately 15 to 25 percent of liver activity; sulfates (after acid treatment) accounted for about 60 percent. Machlin (5) reported that about 20 percent of the sulfur from Na<sub>2</sub>S<sup>35</sup>O<sub>4</sub> that is retained by chickens is incorporated into body taurine. We found that, regardless of the ration, chickens retained initially 50 to 75 percent of a given oral dose of Na<sub>2</sub>S<sup>35</sup>O<sub>4</sub>, and by 10 to 14 days, 15 to 30 percent had not been excreted. We also confirmed in a preliminary way the reported (2, 3) rapid uptake of radio sulfate into the mucopolysaccharide-mucoprotein "organic" sulfate fractions isolated from connective tissues.

Our work indicates that the chicken can satisfy part of its total sulfur requirement with inorganic sulfate. The sulfur amino acids meet much larger fractions of this sulfur requirement. However, large quantities of either methionine or methionine hydroxy analog did not appear completely able to satisfy the total sulfur re-

quirement when they were administered to rapidly growing chickens that were fed a cystine-low, inorganic-sulfur-free diet. Cystine, added to such diets (provided that methionine was not limiting), did satisfy the requirement under these conditions when it was added at sufficiently high levels. Inorganic sulfate cannot replace dietary cystine or methionine for protein synthesis, and studies with Na<sub>2</sub>S<sup>35</sup>O<sub>4</sub> appear to confirm these results, although sulfate apparently will "spare" dietary sulfur amino acids for protein synthesis. The effect of elemental sulfur and inorganic compounds of sulfur, the metabolism of S<sup>35</sup> and Na<sub>2</sub>S<sup>35</sup>O<sub>4</sub>, the effect of sulfate on methionine-deficient diets, as well as a more detailed account of the work reported here, is in preparation.

RICHARD S. GORDON  
*Monsanto Chemical Company,  
St. Louis, Missouri*

IRWIN W. SIZER  
*Massachusetts Institute of Technology,  
Cambridge, Massachusetts*

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6. We wish to express our appreciation to G. M. Briggs, National Institutes of Health, and L. J.

Table 1. Effect of Na<sub>2</sub>SO<sub>4</sub> and graded levels of sulfur amino acids and analogs on growth of chickens.

Ration and supplements	Gain (g)	Standard error*	Feed efficiency†	Feather score‡
<i>Five weeks</i>				
Basal (LC2MS)¶	371.5	24.5	2.84	1.2
Basal + 0.5% Na <sub>2</sub> SO <sub>4</sub>	488.1	24.6	2.70	3.6
Basal + 0.22% DL-methionine	516.7	23.8	2.43	1.8
Basal + 0.22% methionine hydroxy analog	521.0	19.7	2.41	2.1
Basal + 0.22% analog + 0.5% Na <sub>2</sub> SO <sub>4</sub>	617.0	16.4	2.38	3.8
<i>Three weeks</i>				
Basal (LC2MS) #	119		4.01	
Basal + 0.5% Na <sub>2</sub> SO <sub>4</sub>	214		2.54	
Basal + 0.22% DL-methionine	163		2.26	
Basal + 0.22% DL-methionine + 0.5% Na <sub>2</sub> SO <sub>4</sub>	301		2.15	
Basal + 0.44% DL-methionine	259		2.46	
Basal + 0.44% methionine hydroxy analog	263		2.36	
Basal + 0.49% analog	274		2.14	
Basal + 0.44% analog + 0.5% Na <sub>2</sub> SO <sub>4</sub>	308		1.71	
Basal + 0.4% L-cystine	311		1.75	

\* Standard error for one group of 10 to 12 New Hampshire cockerels raised in starting batteries of conventional type with raised wire screen floors.

† Feed consumed divided by weight gained. Under these conditions, an improvement (less feed consumed per unit gain) in excess of 0.10 was found to be significant.

‡ Average of scoring by two persons of each group; a difference in excess of 0.5 was found to be significant on a scale of 0 to 4.0.

¶ 4.1 g MgCl<sub>2</sub>, 0.37 g MnCl<sub>2</sub>, and 0.03 g CuCl<sub>2</sub> used instead of corresponding sulfates in salts "A."

|| Calcium dl-2-hydroxy, 4-methylthiobutyrate.

# 1.1 g MgO, 0.32 g MnO<sub>2</sub>, and 0.03 g CuCl<sub>2</sub> used instead of corresponding sulfates in salts "A."

Machlin, U.S. Department of Agriculture, for their disclosure of unpublished data as well as for advice and suggestions. Machlin has recently confirmed, and in some instances extended the findings reported here.

7. Salts "A" contained, in grams per 60 g, the following compounds:  $\text{CaCO}_3$ , 15;  $\text{K}_2\text{HPO}_4$ , 9;  $\text{Na}_2\text{HPO}_4$ , 7.3;  $\text{Ca}_3(\text{PO}_4)_2$ , 14;  $\text{NaCl}$ , 8.6;  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ , 5; ferric citrate, 0.4;  $\text{MnSO}_4 \cdot 4\text{H}_2\text{O}$ , 0.42;  $\text{KI}$ , 0.04;  $\text{ZnCO}_3$ , 0.02;  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ , 0.02.
8. Choline chloride was added as 0.2 percent of the final ration and the following were added as indicated (in milligrams per kilogram): thiamine HCl, 8; riboflavin, 8; calcium pantothenate, 20; nicotinic acid, 100; pyridoxine HCl, 8; D-biotin, 0.3; folic acid, 3; vitamin  $\text{B}_{12}$ , 0.02; menadione, 1; vitamin-A acetate, 3; alpha-tocopherol, 10; vitamin D<sub>3</sub>, 0.02.

25 July 1955

### Synthesis of Rubber by Fungi

Rubber, as *cis*-polysoprene, was isolated and identified from benzene extracts of sporophores of species of the genera *Lactarius* and *Peziza*. This is believed to be the first evidence of rubber synthesis by microorganisms.

Species of the latex-bearing genus *Lactarius* were collected throughout the growing season in the Brecksville, Ohio, area. Since some species were not abundant, the sporophores of the various species were combined and preserved in ethanol. All species of this group had white latices that did not discolor in air. Sporophores of *L. deceptiva* appeared in large numbers. These were preserved separately. Ascocarps of several saprophytic species of *Peziza* were observed to be rubbery. These were collected and preserved in ethanol.

The carpophores were separated from the ethanol and ground in a meat grinder. The coarsely-ground material was placed in a stainless steel sleeve of fine mesh and extracted for 24 hours with acetone in a large Soxhlet-type extractor. Both alcohol and acetone extracts were evaporated to dryness and the total solids were determined.

The acetone-extracted mycelia were then extracted for 24 hours with redistilled benzene that contained 0.1 percent N,N-diphenyl-p-phenylene-diamine as antioxidant. The benzene extracts, blanketed with nitrogen, were reduced to known volume and aliquots were removed for characterization, for intrinsic viscosity measurements, for total solids, and for cure.

A highly purified sample of *Hevea* rubber was prepared for use as the reference standard for infrared in the following manner. Natural rubber crepe (120 g) was placed in a 6-lit erlenmeyer flask and extracted twice with 2-lit portions of boiling acetone. The acetone-extracted crepe was then placed in 6 lit of redistilled benzene and kept 4 days at room temperature. The benzene-soluble rubber was separated from the gel rubber, which

retained most of the protein, by filtration through a fine mesh stainless steel screen. The clear, colorless rubber solution, about 3 lit, was added to an equal volume of acetone. The precipitated rubber was separated, redissolved in benzene, and again precipitated with acetone. The precipitated rubber was dissolved in 4 lit of benzene and filtered through a coarse filter paper. The filtrate of about 25 g of rubber in benzene was placed in a bottle and blanketed with nitrogen. Phenyl-β-naphthylamine, 0.1 percent on the rubber was added as antioxidant. All work was done under nitrogen.

An aliquot of the reference sample was taken and prepared for analysis. The benzene was removed with nitrogen. The resulting film, after 24-hour storage under vacuum over potassium hydroxide, was submitted for analysis with some of the original crepe. Nitrogen content of the reference sample was 0.03 percent, whereas that of the original crepe was 0.45 percent. The carbon and hydrogen values of the purified rubber were 87.90 percent and 11.69 percent, respectively. The theoretical values are 88.15 percent and 11.85 percent.

Infrared spectra of films deposited from benzene extracts of the fungi and from the reference samples were obtained with the B. F. Goodrich infrared spectrophotometer. The films were prepared by evaporating the benzene extracts on sodium chloride disks with nitrogen.

The limiting intrinsic viscosity  $[\eta]_0$  of the polymer extracted by benzene from the mixed species of *Lactarius* was determined. Viscosity measurements were

Table 1. Intrinsic viscosity measurements on polymer from *Lactarius* sp;  $\eta_r$  is the relative viscosity. A plot of  $\ln \eta_r/\text{concentration}$  versus concentration gave a limiting intrinsic viscosity  $[\eta]_0$  of 0.29. This yielded an estimated viscosity average molecular weight of 13,900 using Eq. 1.

Concentration (g/100 ml of benzene)	$\ln \eta_r/\text{concentration}$
1.017	0.281
0.508	0.285
0.254	0.298
0.127	0.296
0.127	0.281

made at  $25^\circ \pm 0.01^\circ\text{C}$  with Cannon-Fenske viscosimeters. The data obtained at varied dilutions are shown in Table 1.

The sporophores of the mixed *Lactarius* species contained, on a dry-weight basis, 1.7 percent of a rubbery polymer that was soluble in benzene. The infrared absorption curve (Fig. 1) shows that the rubber is *cis*-polysoprene. Its curve is identical with that of *Hevea* rubber except for the carbonyl peak at 5.8  $\mu$ . This may be ascribed either to an impurity or to oxidative degradation of the rubber during extraction.

The  $[\eta]_0$  values of the polymer in benzene at  $25.00^\circ\text{C}$  was 0.29. In order to estimate the molecular weight  $M$ , we employed the equation

$$[\eta]_0 = 5.02 \times 10^{-4} M^{0.49}, \quad (1)$$

which indicated a viscosity average molecular weight of 13,900 for the polymer.

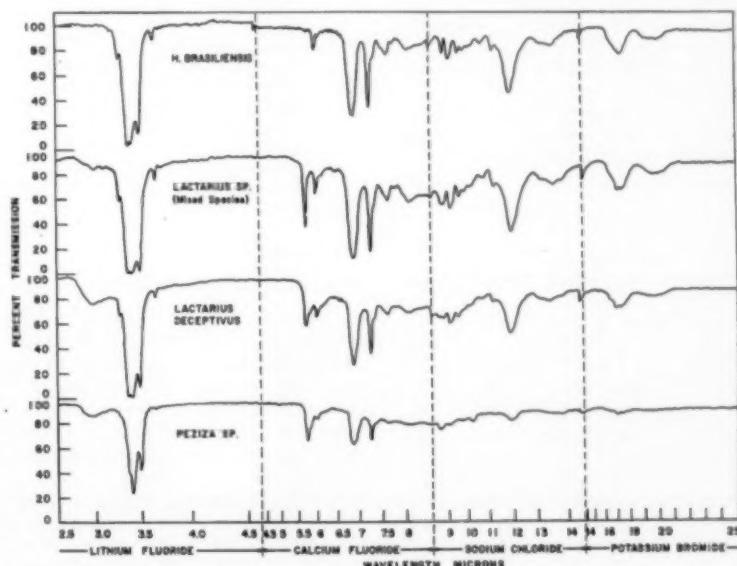


Fig. 1. Comparison of the infra-red absorption spectra of benzene extracts of various fungi with the spectrum of purified rubber from *H. brasiliensis*.

This equation was derived by W. Carter, R. Scott, and M. Magat for natural rubber in toluene (1). Since toluene and benzene have similar  $\mu$  values for natural rubber, the equation was employed for the purpose of estimating molecular weight of the polymer in benzene. The molecular weight of the rubber is low; however, benzene would not extract polymer of high molecular weight—that is, gel rubber—even if it were present. A better method of extraction is needed. Since this is a mixed collection, some species are probably contributing more than the average content of 1.7 percent rubber.

An attempt was made to cure the soft, tacky, low-molecular-weight rubber using the "Peachy" cure and sulfur chloride. The cured products were of low moduli, and elongations did not exceed 200 percent. There was insufficient material for milling to incorporate curing agents.

Rubber extracted from sporophores of *L. deceptiva* was similar to that obtained from the mixed species. It too was *cis*-polyisoprene (Fig. 1). The rubber content was low—0.16 percent on a dry weight basis. It was not characterized further.

The rubber extracted from ascocarps of *Peziza* was much tougher than that from *Lactarius*. Solubility in benzene was very low and deposition of polymer on the salt cakes was not uniform. Satisfactory films were not obtained, but the infrared spectrum (Fig. 1) suggests that this rubber is also *cis*-polyisoprene.

Fungi belonging to two of the major classes of fungi, Ascomycetes and Basidiomycetes, are able to synthesize rubber as *cis*-polyisoprene. Since fungi, phylogenetically, were derived from algae—that is, they are degenerate forms with loss of chlorophyll—the probability of rubber synthesis by species of this phylum is implied.

W. D. STEWART,\* W. L. WACHTEL,\*  
J. J. SHIPMAN, J. A. YANKO

*Research Center, B. F. Goodrich  
Company, Brecksville, Ohio*

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- \* Present address: Atlantic Research Corporation, Alexandria, Va.

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### Arsenic Tribromide Immersion Liquids of High Index of Refraction

Immersion liquids of high index of refraction containing arsenic tribromide as the solvent, prepared in recent years (1, 2), have proved to be stable. In Table 1 are given the starting materials and their relative proportions by weight used to

Table 1. Arsenic tribromide immersion liquids. Composition is given in relative proportions by weight. Dispersion is measured by the difference in index between the  $\epsilon$  line of mercury (546 m $\mu$ ) and the  $D$  line of sodium (589 m $\mu$ ).

Composition	$n_D$ ( $\times 10^{-3}$ )	Time	$dn/dT$ ( $\times 10^{-4}$ )	Dispersion
6AsBr <sub>3</sub> , 2S <sub>2</sub>	2.00	-2	1 1/4	6 (1)
6AsBr <sub>3</sub> , 2Se <sub>2</sub>	2.11	-2	3	6 288
12AsBr <sub>3</sub> , 1S <sub>2</sub>	2.07	-1	2 1/2	
6AsBr <sub>3</sub> , 2Se <sub>2</sub>	2.04	-2	3	
14AsBr <sub>3</sub> , 3S <sub>2</sub>	1.99	-1	3	6 173
14AsBr <sub>3</sub> , 3S <sub>2</sub>	2.01	-3	3	
6AsBr <sub>3</sub> , 2S <sub>2</sub> , 2HgS	2.02	-1	3 1/2	6 195
CH <sub>3</sub> I <sub>2</sub>	1.74		7 (4)	88 (1)

prepare the liquids, the indices of refraction of the liquids ( $n_D$ ), the change in index of refraction with time ( $\Delta n_D \times 10^{-3}$ ), and the temperature coefficients ( $dn/dT$ ) and dispersion of some of the liquids (3). The liquids were prepared as described in an earlier paper (1). The disadvantages of the arsenic tribromide liquids have been listed in a more recent publication (2).

The liquid with an index of 2.11 is very viscous and dark red, but a thin film is light yellow. It is possible that even higher indices can be obtained with these mixtures.

ROBERT MEYROWITZ

*U.S. Geological Survey,  
Washington, D.C.*

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### Mechanism of Antibody-Antigen Reaction

Antisera to yeast crystalline alcohol dehydrogenase (1) were produced in rabbits by subcutaneous injections of 10 mg at weekly intervals. The antibody partially inhibited the activity of the enzyme but did not inhibit liver alcohol dehydrogenase. The enzyme (antigen) reacted with the antibody to form a precipitate of antibody-antigen complex that nevertheless possessed enzymatic activity (2). Kinetic studies on the inhibition of the enzyme activity with increasing increments of antiserum (3) led to the formulation of the following concept.

When an antigen is first introduced into the body, it stimulates the formation of specific antibodies to special sites on its surface that possess the necessary configuration. If it is still present in the body or is again introduced into the animal at a time when antibodies are already present in the circulation, it reacts rapidly with these earlier antibodies to form an antibody-antigen complex (complex I). This complex, in which the configuration of the antigen and antibody are mutually altered, behaves as a new antigen. Specific antibodies are then formed against the new sites of altered configuration. Similarly, if the antigen is still present in the body, or upon the introduction of the antigen for a third time, the earlier antibodies react with it to form complex I, which then reacts with its specific antibody to form complex II, and this in turn behaves as a new antigen with a newly altered antigenic surface. Complexes III and IV, and subsequently others, may be formed in like manner. This process presumably continues with each introduction of the antigen until a stage is reached when the final complex ceases to be antigenic or fails to differ antigenically from the immediately preceding complex.

The concept just developed represents no departure from already accepted principles of immunology and protein chemistry. There are many examples of compounds, termed *adjuvants*, that act on some substances to influence their immunological reactivity (4). Furthermore, a staphylococcus toxin reacts with rabbit muscle extract to render it antigenic when it is injected into rabbits (5).

Proteins are capable of astonishing structural transformations. They can unfold to expose new groups, hydrophilic or hydrophobic as the case may be, depending on the environment (6). It is therefore to be expected that the structural configuration on the surface of the antibody-antigen complex must necessarily differ at certain sites from the original configurations of the individual antigen and antibody. It has already been shown that an antibody molecule does in fact increase in volume upon reacting with the antigen (7). Such an increase in volume is interpreted to signify an unfolding of the molecule with a structural modification of its surface configuration. The very fact that a precipitate is formed can readily be explained by the unfolding of both antibody and antigen so as to expose a large number of hydrophobic groups.

In support of this concept, it has been possible to show the following (8).

- 1) The subcutaneous injection of a thoroughly washed antibody-antigen complex into rabbits produced antiserum that reacted more rapidly with the complex than with the enzyme antigen itself. This

reaction was measured by the rate of increase in turbidity and by the rate of inhibition of the enzymatic activity in each case, using the Beckman spectrophotometer at 340 m $\mu$ . The complex was prepared in all instances at the equivalence point. After an incubation of antiserum and antigen for 24 hours at 0°C, the mixture was centrifuged and washed three times with 5 ml of saline at 0°C.

2) It was also possible to show (Table 1) that one can absorb selectively and exhaustively with a particular complex and yet leave behind in the supernatant other antibodies that can react with the original antigen. Table 1 further shows that with one injection no antibody to a particular complex is detectable. With repeated injections, however, there is a simultaneous rise in the amount of antibody that reacts with the complex.

3) Table 2 shows in addition that one can absorb in a similar manner with two types of complexes and still detect antibodies left behind that react only with the original antigen. Furthermore, Table 2 shows that when absorption of antibody was done with the original antigen alone, the amount of antibody that precipitated was in accord with the sum of the antibody absorbed on the two complexes and that which was subsequently absorbed on the antigen. This indicated that the antigen formed a nucleus for the succeeding complexes, which in turn absorbed their respective antibodies.

According to this concept, the "univalent" or "incomplete" (9) antibody would have all the characteristics of an antibody to the complex. Furthermore, this concept readily explains certain anomalies recently observed in antibody-antigen reactions. It was reported that

Table 2. Antisera that are completely absorbed with one antigen-antibody complex may nevertheless contain antibody for a second antigen-antibody complex; the supernatant fluid then contains residual antibodies that are reactive only with the simple antigen. The numerical values indicated in the antiserum code refer to the number of subcutaneous weekly injections of 10 mg of antigen given before serum was obtained. Serums No. 1 and 2 were absorbed by successive additions (I to IV) of 0.5 mg of the first complex and 0.3 mg for each subsequent addition (V to VII) of the second complex. The first complex was prepared from a rabbit serum obtained after nine injections of antigen, and the second complex was prepared from a rabbit after five injections of antigen. Serums No. 3 to 5 were similarly absorbed by 1.0 mg and 0.6 mg of the first and second complex, respectively. The first complex used in the last three experiments was prepared from a rabbit serum obtained after five weekly injections of antigen, and the second complex was prepared from a rabbit serum obtained after two injections of antigen. The amount used for absorption was dictated by the total amount of antibody present. Incubation time was 2 hours at 30°C, followed by 1 hour at 0°C at pH 8.25. The amount of antigen (enzyme) precipitated when antigen in slight excess was subsequently added (VII), or when it was added alone as in column 10, was calculated from the specific activity added minus the activity remaining in the supernatant. Normal serum was used as control.

Antiserum	Antibody absorbed (μg of protein/ml of antiserum)								
	Successive absorption (I to VII)								
	First complex				Second complex		Antigen		Antigen alone
	I	II	III	IV	V	VI	VII	Total	
1 (D-2)	140	10	0	0	102	0	90	332	300
2 (A'-5)	100	90	60	0	156	0	118	524	580
3 (A-2)	670	195	0	0	0	0	815	1680	1550
4 (A-3)	80	195	0	0	160	0	1420	1855	
5 (F-7)	1170	322	0	0	180	0	1460	3132	3120

Rh antisera fractionated by the electrophoresis convection method showed a considerable loss of total precipitating antibody when each fraction was measured separately. However, on recombination of the fractions, there was complete recovery of the antibody (10). It is apparent now that the different fractions contained limiting amounts of antibody to one or another complex. Conse-

quently, only a portion of the antibody present in a fraction could be precipitated under the circumstances.

VICTOR A. NAJJAR

JEAN FISHER

Department of Pediatrics, Johns Hopkins University School of Medicine, and Johns Hopkins Hospital, Baltimore, Maryland

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Table 1. Presence in antisera of antibodies to crystalline alcohol dehydrogenase that react uniquely with the simple antigen after complete absorption with an antigen-antibody complex. Antisera were obtained from the same rabbit 1 week after the first, second, and third subcutaneous injections of 10 mg of enzyme as indicated in column 1. The complex used for the successive additions was prepared from the pooled serum of two rabbits, one receiving three and the other five weekly injections of 10 mg of enzyme. One milligram of complex was used for each successive absorption, and 0.06 mg of enzyme, representing a slight antigen (enzyme) excess, was used in the final step. Incubation time for each absorption was 24 hours at 0°C at pH 8.2. Normal rabbit serum was tested simultaneously under the same conditions as the immune serum and consequently served as control.

Weekly injections	Antibody absorbed per milliliter of antiserum with successive additions (I to VI) of the same complex followed by addition of antigen (μg/ml)						
	Complex						
	I	II	III	IV	V	VI	Antigen
1st	0	0					240
2nd	440	410	320	220	180	0	780
3rd	820	620	510	380	270	0	440

*I criticize not by finding fault but by a new creation.*—MICHELANGELO.

## Book Reviews

**The Biology of the Amphibia.** Unabridged republication of ed. 1. G. Kingsley Noble. Dover Publ., New York, 1955. 577 pp. Illus. \$4.95.

Through the interest of and training with that patron of science, Thomas Barbour, the thorough doctoral training of the master scientist, W. K. Gregory, and the sympathetic opportunity given by Mary C. Dickerson, Gladwyn Kingsley Noble began an illustrious career of research, giving his chief attention to amphibians. Being essentially a laboratory scientist in a museum environment, the museum yielded him rich materials and a wonderful library of exceptional bibliographic value, whose staff and his own youthful assistants rendered much help.

By 1906 when Samuel J. Holmes brought out his *Biology of the Frog* the literature had become considerable but in 1931 (the first edition of this work) it was immense. In my opinion the references at the end of each chapter are one of its greatest merits. So much ink has not been expended on any vertebrate form outside man or has been used so extensively in biological classes as on the frog or amphibians. From 1906 to 1931 the work by Holmes in several editions served this purpose either as a textbook or as collateral reading. The coming of Noble's wider text, including salamanders, largely displaced this splendid work of Holmes.

I am glad to see a reissue of Noble's very useful work. In the immediate past several people have asked where they could secure a copy of the original text. I shall not review the various chapter topics, which are much the same as those of Holmes but far more extended. We have no comparable text for turtles, snakes, or lizards.

Fifty years ago I used Ecker and Wiedersheim, G. A. Boulenger's *Tailless Batrachia of Europe*, Gadow's *Cambridge Natural History* volume, and several more, but few emphasized the salamanders as Noble does. By 1931 a simply written, comprehensive volume was much needed, and this work supplied the need. Few could have done this review of the literature without the peculiar American

Museum setup of efficient help. No work has appeared to replace it, and a reprint is in order. If after a quarter of a century it is to be reissued it must be a useful book of exceptional merit.

ALBERT H. WRIGHT

Professor Emeritus of Zoology,  
Cornell University

### Actions of Radiations on Living Cells.

D. E. Lea. Cambridge Univ. Press, New York, ed. 2, 1955. 430 pp. Illus. + plates. \$5.50.

This book, a classic in its field, has been out of print for some time, and those who must refer to it will be glad to know that it is once again available. The revisions consist of some minor textual changes, together with 11 pages of notes and 32 additional references, that the author, before his untimely death, had made as annotations in his personal copy. The work has therefore in no real sense been brought up to date, and workers who want a more recent and extensive treatment of the subject should refer instead to the two parts of *Radiation Biology*, volume I, edited by A. Hollaender (McGraw-Hill, 1954).—B.G.

Catalogue of the Type Specimens of Microlepidoptera in the British Museum (Natural History) Described by Edward Meyrick. vols. I and II. J. F. Gates Clarke. British Museum of Natural History, London, 1955. Illus. vii + 332 pp. and 531 pp. £3 and £6.

Most of us dream at times of bringing order into whole vast fields of human knowledge, but few of us have the energy, persistence, or even the proper circumstances actually to do any such thing. We can only admire, envy, or marvel at those who do. Gates Clarke, in the projected six volumes of Meyrick's type specimens, comes close to reorganizing the entire field of the taxonomy of the microlepidoptera. Of this work two volumes are at hand, the third is partially

in press, and the remaining three are expected to appear during the next 5 years.

Edward Meyrick (1854–1938), in a publishing lifetime of 64 years, described the incredible total of well over 14,200 species of moths. One wonders if he ever slept! As might be expected with such an output, the work was not always as careful as might have been desired. The basic scheme of classification adopted by him was inadequate and artificial, and many of the characters of great taxonomic value to modern students of these moths were not even described by Meyrick. Consequently, microlepidopterists have been faced for years with the enormous task of combing through this immense mass of literature and these innumerable specimens to bring them into accord with present-day ideas and to organize them so that a modern worker would at least know which of Meyrick's species belonged to a group that he might have under consideration. Even to bring together the bibliographic citations for upward of 14,000 names would be a many-years' task for most ordinary people. Clarke has done this as a mere introductory list in the present work. It occupies the greater part of volume 1 of the series, along with discussions of Meyrick's specimens, labeling, and classification. These latter discussions might well be made required reading for students of taxonomy, both plant and animal.

Volume 2, treating the families Stenomidae, Xyloryctidae, and Copromorphidae, may be taken as an example of the five main volumes of the Catalogue. This volume consists of 531 large octavo pages of which 263 are fine halftone plates illustrating the wings and genitalia of generally four species each. The remaining pages are text for each species, giving Clarke's disposition of them, sometimes with brief excerpts from the original publication, synonymy, designation of the type, and explanation of the figures in the accompanying plates. Glancing over plate after plate of these moths, one is at the same time impressed by both the monotonous similarity and the infinite variability of these delicate creatures. After seeing the variation that occurs in the pattern of even a single genus, one ceases to be surprised that the Lepidoptera are the second largest group of living organisms in number of species. These illustrations are made from enlarged photographs of expanded wings and microphotographs of genitalia, usually in two views. Each of these represents a careful dissection done by Clarke himself.

In the text are many hundreds of new combinations, needed to bring the greater number of the insects treated into line with modern taxonomic arrangements. An interesting difference between zoological and botanical practice in nomenclature

ture is brought out strikingly in this connection. In many cases new combinations are made for specific names originally proposed in wrong genera, which are then, even on the same page, reduced to synonymy under other species. This seems to be perfectly correct zoological practice, but most botanists scrupulously avoid making unnecessary new combinations. Perhaps the bogey of adding to synonymy has been grossly overemphasized by botanists, since this wholesale creation of new binomials does not seem to inconvenience the zoologists in the least.

In sizing up the character and importance of this series, one may say that it seems to set the pattern for much of the most needed taxonomic work in both zoology and botany during the next century.

F. R. FOSBERG

National Research Council

#### Classical Electricity and Magnetism.

Wolfgang K. Panofsky and Melba Phillips. Addison-Wesley, Cambridge, Mass., 1955. xi + 400 pp. Illus. \$8.50.

After teaching for a long time from notes and by a multitude of references, it is good to find in a single book material of which one can say, "This is written just about the way I would like to have it done." No two teachers would agree in detail on what should be included in any textbook, but most will feel that this one contains a well-balanced assembly of topics for a graduate course. There is material on wave guides and cavities and material on scattering. Relativistic electrodynamics and the fields from a moving charge are discussed at some length.

The use of meter-kilogram-second units in a book having the stature of this one will speed their acceptance among physicists. Conformal mapping and the Schwarz transformation are treated too lightly to enable the student to work the assigned problems. A scalar magnetic potential that arises from conduction currents is defined, but another that arises from magnetization is also defined. The same symbol is used for both. A little maneuvering could show that the two are identical, but the student may well think that they are distinct. It has always been hard to find problems for an advanced electromagnetics course that are of just the right degree of difficulty; the present book does much to relieve that situation.

The adverse criticisms are trifling ones. This is an excellent book that gives in one volume material that has been scattered throughout many books.

ROBERT H. WHITMER

Rensselaer Polytechnic Institute

#### Experimental Design and Its Statistical Basis.

D. J. Finney. Univ. of Chicago Press, Chicago, Ill., 1955. xi + 169 pp. \$4.50.

This book is in the series entitled "The Scientist's Library: Biology and Medicine," for which the editor's specifications included emphasis on introductory concepts and problems, assumption of a "common level of scientific competence" among readers, and avoidance of popularization—not easy specifications to meet in the subject of this volume. The author had to write principally for those biologists and medical research workers, still numerous, who are unfamiliar with the past 30 years' developments in the logic, and consequent practice, of experimentation; therefore he had to risk revealing that much of his potential readers' experimentation involves biased or inefficient designs and hazy inferences.

Even if a reader starts with a conception of statistics as some arithmetic for use after an experiment, he can hardly retain that notion after seeing this comprehensive up-to-date presentation of principles with illustrations from a wide variety of experiments on animals and plants, in field and laboratory, and from human therapeutic trials.

The author writes "in the hope of arousing interest," and makes "no claim that the subject is easy, but only that those who will rid themselves of the fear of mathematics can understand much without using advanced mathematical techniques." His advice with reference to some sections—to pass over difficulties without struggling with them greatly—could well apply to any passages that are difficult on the first reading.

One of the book's virtues is that probably no one will learn from it enough arithmetic to swell the multitude of misleading  $t$ 's and  $\chi^2$ 's in current medical and biological literature—products of an unfortunate sequence in the development of modern statistics; namely, the dissemination of arithmetical techniques before the emergence of experimental methods (such as strict randomization) that are essential to justify the arithmetic after an experiment.

A good book stimulates one to suggest possible improvements, and here are three suggestions.

1) Does not even a brief display of the arithmetic of  $\chi^2$  and of  $t$ , early in an exposition of experimental design, tend to orient the reader in an undesired direction?

2) Is not the justification of normal (Gaussian) curve methods—an admittedly uncomfortable but fundamental question—too brief? It is to be hoped that, as experimenters become more at home with statistical thinking, they will

raise this question insistently. An introductory book could, perhaps, best anticipate such inquiry by pointing out the distinction between techniques of design (such as the Latin square and randomization), which can be justified by well-known properties of our universe, and normal-curve techniques of analysis, which are justified for some phenomena by extensive experimentation and for others by little more than the statistician's analog of "clinical instinct."

3) The last sentence of the text rightly says that any biologist who has read the book will realize the need for a statistical specialist's advice—a very desirable outcome; but one could wish for a few remarks on problems met by a statistical consultant who continues to conduct his own experimental research. Such a person knows how constant must be the vigilance if bias is to be avoided that will render any statistical tests or estimates highly questionable. He knows how scarce statisticians are compared with the myriads of researchers that need statistical aid throughout. He is faced with colleagues' demands for statistical analysis of their data, often prompted by journal editors or arithmetically minded referees who are willing to assume that an experiment was suitable for such treatment.

On the other hand, he knows that many experiments, not suitable for statistical arithmetic, have led toward the truth because the data have been produced and assessed by a skilled and self-critical experimenter who has arrived at a cautious conclusion—statistical, it is true, but without the spurious definiteness of a P value or a confidence limit.

When a book tends to increase the demand for a scarce commodity, it would not be unfitting for it to give advice to those who wish to obtain the commodity but can obtain little or none of it.

DONALD MAINLAND  
New York University College  
of Medicine

**The World We Live In.** Lincoln Barnett and editorial staff of *Life*. Time, Inc., New York, 1955. 304 pp. Illus. \$13.50, regular ed.; \$15.50 deluxe boxed ed.

When the judges met in 1953 to select the winners of that year's AAAS-George Westinghouse Science Writing awards, they unanimously voted a special citation to *Life*'s science department and Lincoln Barnett for the series of articles then appearing in *Life*, *The World We Live In*.

The series has since been completed and is now available in book form. In 1953 the judges considered the magazine

series "a distinguished example of science journalism." So is the book. The 13 chapters cover the physical history of the world, from the birth of the earth, and the universe of which it is a part, through geologic change and biological evolution, to the world of today with the varied life forms of its major climatic regions. In an introduction Vannevar Bush calls it a "lucid, interesting and withal accurate account of the world we live in . . . [it] will captivate the imagination of millions of non-scientific people who would otherwise not concern themselves with its subject matter. No pains were spared to make it accurate. Many scientists were consulted and gave their best advice to make its statements true and accurate in scale. The result is a natural history in modern dress . . . which should delight as well as instruct a vast number of people."

Indeed many scientists were consulted, some 250 of them from the United States and other countries, plus a dozen and a half scientific institutions.

The *Illus.* in the bibliographic citation is a pale understatement of the scores and scores of excellent photographs and paintings. In black and white and in color, from a few square inches in size to double-page spreads, the illustrations are the heart of the book and its justification. The text explains, sometimes amplifies, and gives continuity. But the illustrations catch the eye first and will probably be turned to again and again after the text is read.

The book is not only excellent science journalism but appears likely to become one of the most successful of all ventures in this field. *Life* received more than 400,000 requests for reprints of the magazine articles and reported an advance sale of approximately half a million copies of the book. The success is deserved, for the authors, photographers, painters, and publishers have done an excellent job.—D.W.

**Introductory Nuclear Physics.** David Halliday. Wiley, New York; Chapman & Hall, London, ed. 2, 1955. ix + 493 pp. Illus. \$7.50.

In a rapidly expanding field of research such as nuclear physics, textbooks must be frequently revised to include new information and new theoretical ideas. The second edition of Halliday's book on nuclear physics, first published in 1950, has been substantially improved. The book is designed for an advanced undergraduate course and introduces the student to the entire field of nuclear physics. Shortened by 65 pages with the elimination of much experimental detail and the frequent use of small type, the new

edition is made more valuable by the extended treatment of theoretical ideas underlying nuclear physics. The experimental information has been brought up to date, and the author has continued his practice of making many references to original articles. Thus the book is valuable as a reference as well as a textbook. The author has included many good problems and has retained his easy informal style that makes the book a pleasure to read.

Although a considerable familiarity with the basic ideas of atomic and nuclear physics is assumed, a chapter on the elements of quantum mechanics has been added to allow a more thorough treatment of nuclear theory as the various problems arise. Several results of theory that were simply stated in the first edition are explained in greater detail in the text or in a series of appendixes treating aspects of wave mechanics and other theoretical problems. The subject of gamma radiation and internal conversion has, for example, been expanded from a few pages to a full chapter.

Other new chapters are concerned with two-nucleon systems and the passage of charged particles and gamma rays through matter. The chapter on cosmic rays has been condensed and a new section has been added on subnuclear particles. The chapters on detectors of nuclear particles and accelerators, brought up to date in this edition, will be useful to beginning research students.

WILLIAM B. FRETTER

Department of Physics,  
University of California, Berkeley

**Radioisotopes in Biology and Agriculture: Principles and Practice.** C. L. Comar. McGraw-Hill, New York-London, 1955. xiii + 481 pp. Illus. \$9.

There are now in existence many books covering applications of radioisotopes to biological studies. The inclusion of details of typical experiments on large domestic animals and on plants and fertilizers is the main feature that distinguishes *Radioisotopes in Biology and Agriculture* from other books in this field. For this reason it should be attractive to investigators in agricultural biology.

The sections dealing with general principles of radiotechniques are well organized and presented with sufficient simplicity and clarity to be understandable to a beginner. The chapter entitled "Basic difficulties in tracer methodology" is especially well presented and covers the problems of purification, radioactive decomposition, and isotope effects that should be emphasized to students in this field.

One of the surprising features of this

average-sized book is the amount and nature of the reference material. Included are a glossary of terms in nuclear science, tables of solvent systems and reagents for paper chromatography and for column chromatography, a table comparing various commercial filter papers, and a table listing various ion-exchange resins and their properties. The latter are accompanied by discussions of principles and operation of chromatography. Although these excellent sections on chromatography are intended to serve as handy reference sources, they may unfortunately find little use, since few investigators may think of referring to a text on radiotechniques for detailed information on chromatography.

I was somewhat surprised to find that so few of the illustrating experiments presented deal with  $C^{14}$ , since it is the radioisotope most used in biological studies.

*Radioisotopes in Biology and Agriculture* is an excellent book. To researchers in agriculture it offers something hitherto unavailable. As far as general biology is concerned it is now one of many good textbooks on radiotechniques.

SIDNEY UDENFRIEND  
National Institutes of Health

## New Books

*The Coast Salish of British Columbia.* Homer G. Barnett. Univ. of Oregon, Eugene, 1955. 320 pp. \$5.

*Vector Analysis.* Homer E. Newell, Jr. McGraw-Hill, New York, 1955. 216 pp. \$5.50.

*The Geometry of Geodesics.* Herbert Busemann. Academic Press, New York, 1955. 422 pp. \$9.

*Éléments de Mécanique Quantique.* Ph. Pluvigné. Masson, Paris, 1955. 547 pp. Broché, F. 4000; cartonné toile, F. 4600.

*Actions Chimiques et Biologiques des Radiations.* M. Haissinsky, Ed. pt. 1, *Aspects Physiques de la Radiobiologie*; L. H. Gray, pt. 2, *Chimie des Radiations des Solutions Aqueuses. Aspects Actuels des Résultats Expérimentaux*; M. Lefort, pt. 3, *Modern Trends in Radiation-Biochemistry*; W. M. Dale. Masson, Paris. 1955. 254 pp. F. 2800.

*A Century of Progress in the Natural Sciences, 1853-1953.* Published in celebration of the centennial of the California Academy of Sciences. California Acad. of Sciences, San Francisco, 1955. 807 pp.

*Biochemistry and the Central Nervous System.* Henry McIlwain. Little, Brown, Boston, 1955. 272 pp. \$9.50.

*An Introduction to Reactor Physics.* D. J. Littler and J. F. Raffle. McGraw-Hill, New York; Pergamon, London, 1955. 196 pp. \$4.50.

*How to Make Cacti Flower.* E. Lamb. Pitman, New York, 1955. 80 pp. \$1.95.

*Family and Fertility in Puerto Rico.* A study of the lower income group. J. Mayone Stycos. Columbia Univ. Press, New York, 1955. 332 pp. \$6.

## Scientific Meetings

### Religion in the Age of Science

From the point of view of perhaps most theologians and scientists, it would seem unlikely that in the middle of the 20th century a group of reputable scientists and theologians would meet together, at least for any common professional business. And it might be considered improbable that they should come to some common understanding of a positive relationship between theology and science, or that they should proceed to set up a joint program for the creative advance of religion hand in hand with science. Yet this seems to be what took place at the second summer Conference on Religion in the Age of Science, which was held on Star Island, off Portsmouth, N.H., during the week of 30 July to 6 August.

At the end of the week, conference leaders announced the establishment of the Institute on Religion in an Age of Science "to promote creative efforts leading to the formulation, in the light of contemporary knowledge, of more effective doctrines and practices for human welfare." The following 22 persons, who were leading contributors to the thinking of the conferences, were elected to the governing board of the institute: Carl Bihldorff, First Parish, Brookline, Mass.; Edwin P. Booth, Boston University, president; Marion J. Bradshaw, Bangor Theological School; Ralph W. Burhoe, American Academy of Arts and Sciences, secretary-treasurer; Karl W. Deutsch, Massachusetts Institute of Technology; Alfred E. Emerson, University of Chicago; Philipp Frank, Harvard University; Dana McL. Greeley, Arlington Street Church, Boston, Mass.; Gerald Holton, Harvard University; Roy G. Hoskins, Office of Naval Research, Boston, Mass.; A. G. Huntsman, University of Toronto; Edwin C. Kemble, Harvard University; Henry Margenau, Yale University; M. F. Ashley Montagu, Princeton, N.J.; Henry A. Murray, Harvard University; Henry Bayard Phillips, emeritus, Massachusetts Institute of Technology; Lyman V. Rutledge, Community Church, Dublin, N.H.; Paul E. Sabine, Colorado Springs, Colo.; Harlow Shapley, Harvard University; B. F. Skinner, Harvard University; George Wald, Harvard University; and Henry N. Wieman, emeritus, University of Chicago.

In this list there are what William James designated "tough-minded" or hardboiled scientists, including leaders of such seemingly unlikely sources for religious sympathy as the logical positivists, evolutionists, and behaviorists. One may expect to read occasionally of a scientist who says something in favor of religion, although he seldom if ever says that his science offers much real help for it. And one may expect also to read of the efforts to support religion by those usually sincere defenders of a faith who come up with superficially plausible arguments in scientific jargon that for the most part fall down when they are examined by more competent scientists or by good common sense and that are often not even felt pertinent by the more sophisticated religious scholars; these arguments run from claims that scientific evidence supports the idea that the sun stood still to claims of evidence for spiritual beings. However, one does not often expect to read that leaders of those scientific and philosophical schools that are most often held aloft by religionists and humanists as the incarnation of "materialism," "mechanism," and other spiritual demons are seriously involved intellectually in religion. In a brief report for *Science* there is not space to explain the equally (although on different grounds) anomalous position of the theologians in this institute.

But the unexpected has happened. In this age when the unsplittable has been split, we find the beginning of the fusing of the seemingly irreparable split between the domains of our knowledge of "values" and our knowledge of "facts." There was at this conference a genuine meeting of minds that bids fair to let theology down from the embarrassing hook that has held it up and out of contact with the world of reality as pictured by science. At the same time, science is brought into a more creative relationship with problems of human destiny at a level "higher" than that usually designated as material. Perhaps the following quotation from the institute's statement of purpose will give some idea of what is afoot:

"The program of the Institute proceeds in the faith that there is no wall isolating any department of human understanding, and that, therefore, any doctrine of human salvation cannot success-

fully be separated from the realities pictured by science. We believe that science provides rich new insights into the problems of human welfare and offers the possibility of a reformulation of the doctrines about the nature of man and about the nature of that in which he lives and moves and has his being. We think any scientifically substantiated notions may command wider acceptance and provide more effective programs of living for both the individual and society. We believe that any department of human knowledge may yield important contributions, including the physical, biological, and psychological sciences, as well as all fields of scholarship and interpretation of human culture.

"We suspect that, in this search for a clear and modern statement of human values, much of what has been revealed by the great religious teachers of the past will stand forth in new brightness and detail, although we welcome any clearing away of misunderstandings or inadequate doctrines about the nature of reality and values. Certainly, for our times as for any time in the past, it seems that the first and most important task of man is to discover the highest values of his own nature and to orient himself properly with respect to the requirements placed upon his development by the complex and many-dimensioned cosmos."

These purposes and understandings were subscribed to fully as much by the theologians and clergymen as by the scientists at the conference, whose approximately 200 members came from 26 states and Canada and included 2 or 3 dozen who are professionally engaged in scientific work and an equivalent number who are professionally engaged in religious work, as well as laymen of various backgrounds. Included were persons of 15 different Christian denominations and two non-Christian faiths. Representative of the degree to which the theologians concurred with the scientists about the nature of knowledge was the statement by Edwin P. Booth, professor of historical theology at Boston University and a co-founder of the conference, who said, "I do not believe there is a revelational knowledge *and* a rational knowledge. . . . There is no division of knowledge. Science and religion are of the same great pattern, aspects of man's knowledge applied to different areas of his life."

Henry Nelson Wieman said, "It will be a great gain for religion to recognize that no knowledge is possible outside the world of time, space, and process. When this truth is recognized and adopted by religion it will be saved from innumerable illusions, phantasies, and wild aberrations which have driven thousands to disaster." These are not the words of a scientist but of a man who was for many years a teacher and formulator of the

philosophy of religion in the Federated Theological Faculty of the University of Chicago.

Perhaps even more unusual are the following statements of Wieman, which sound as though they could have come from the pages of some logical empiricist: "We know that every instance of knowledge is a proposition about some process going on in the temporal world. To be sure, pure mathematics is not about any process; but mathematics cannot give us knowledge of any actuality until it is applied to the world of process, otherwise called the world of events or happenings or temporality. Any alleged knowledge about an actuality transcending the temporal world is mistaken. One can have beliefs and can speculate about alleged realities which transcend the temporal world. But one can have no knowledge of such Being."

The conferees agreed pretty generally also on what they meant by religion. Psychologist Murray joined theologian Wieman in defining religion not in terms of any particular system of beliefs or concepts but in terms of a problem to be answered: what is the sphere of most concern for man? This is at once a question of fact and of value, and value thus becomes a special class of fact. Zoologist Emerson joined these two men in asserting that it is quite obvious that science has succeeded in discovering elements of the "optimal conditions for living." Emerson put forth his concept of homeostasis, "emerging from physiology and applicable to social science," as a criterion for moral judgment that is measurable and applicable. It is a concept that enables man to understand ethical values through scientific inquiry and research."

What in fact are optimal conditions or highest objectives of life were in general considered to be questions to be answered not only by instinct, intuition, and cultural traditions, but also, at a new and more rapid evolutionary rate, by scientific research. The question of ultimate values or ends (as contrasted with means) such as why is life good or desirable, why should man seek optimal conditions, and so forth, was no more disturbing to the conference than questions of ultimate facts about anything—these ultimates all seemed to lie beyond the reach of the biggest telescopes and the most advanced methods of discovering the structure of the universe, as part of that seemingly inexhaustible mystery that it is our lot to explore.

With this common base concerning the nature of knowledge and religion, the conference proceeded toward the sketching of doctrines about (i) the nature of creation or that from which and in which man has his being, (ii) the nature of man, and (iii) some consequent elements of a program for human welfare. While

there was great care not to violate the well-established elements of scientific knowledge, the perspective of the conference was not limited to the rather mundane and limited problems where science offers succor to man in the most obvious ways; instead, it was extended over the larger perspectives that are common in religious ideas.

The process of creation or evolution was set forth in a thoroughly scientific way by men quite familiar with it—men such as astronomer Shapley, biologists Emerson and Huntsman, anthropologist Montagu, and psychologist Murray. But they went further than the scientist goes ordinarily to cover the purposes of interpreting the restricted field of relationships between the theoretical framework of some special area of the natural sciences and the observed phenomena. They sought to find how this new picture of the nature of creation could be useful from the religious point of view, or, in what way the picture is particularly significant for man's hopes and for guiding human conduct. Since this report cannot go into detail on each of the contributions, readers are referred to the paper in *The Scientific Monthly* [73, 67 (1954)], "Dynamic homeostasis, a unifying principle in organic, social, and ethical evolution" by Alfred E. Emerson, for a sample of the kind of approach that was made to develop elements of a modern religion in the light of science.

RALPH W. BURHOE

Boston, Massachusetts

### Theoretical Physics

A colloquium on theoretical physics was held at the Canadian National Research Council in Ottawa 9 to 17 June 1955 in honor of P. A. M. Dirac, who was to visit the Division of Pure Physics of the council last summer. Unfortunately, owing to illness, Dirac's visit was delayed until July and August; hence he could not be present at the meeting. However, the occasion provided a major landmark in the organization of physics teaching and research in Canada by bringing together for the first time almost all Canadian theoretical physicists and many of the experimental physicists for the discussion and presentation of their research and for meeting visiting physicists from all parts of the United States.

The success of the meeting was not only a tribute to the principal organizer, G. Herzberg, but was also an indication of the importance that meetings and discussions must play in theoretical physics, particularly in Canada where the great distances make it difficult to visit between universities during the academic year. If Canadian physics is not to suffer through work in isolation, it is very important that

a colloquium or a summer school or some similar occasion should be arranged annually. This need was noted at a business meeting held during the colloquium, where it was decided to ask the Canadian Association of Physics to form a theoretical section. It was recognized, however, that the problems involved can be solved only with the cooperation of other scientists, and it is a good sign that the National Research Council was the authority that provided the support necessary for the colloquium last June.

The invited speakers included S. Chandrasekhar who gave a series of five lectures on problems of stability and turbulence in hydrodynamics and magnetohydrodynamics. His lectures on stability were concerned mainly with the development of a theory to describe the onset of thermal instability in a layer of fluid heated below when it is subject to rotation and/or a magnetic field. The theoretical predictions were confirmed by the experiments of D. Fultz and Y. Nakagawa. In his lectures on turbulence, Chandrasekhar described his work in developing a deductive theory of turbulence using the similarity principles of Kolmogoroff. His final lecture presented a theory of hydrodynamic turbulence and described its bearing on the character of the interstellar magnetic field and on Fermi's ideas on the origin of cosmic rays.

Three lectures were given by H. A. Bethe on the scattering of pi-mesons. He showed how the main properties of the meson-nucleon system could be deduced from experiment and gave an account of recent attempts by Chew and Low to relate meson field theory to the observed experimental results. A comprehensive survey of nucleon-nucleon scattering was given by G. Breit in a series of three lectures. This survey included a careful analysis of the experimental data and a discussion of its interpretation in terms of interactions between two nucleons. Other invited speakers included W. A. Watson on the theory of liquid helium, G. M. Volkoff on the Bohr-Mottelson model of the nucleus, R. J. Eden on the Brueckner many-body method in nuclear structure, G. Wentzel on rotational states of nuclei, and V. Weisskopf, who lectured on nuclear reactions, on the neutron-proton mass difference, and on his work with K. Gottfried on an independent particle model of the nucleus using a nonspherical potential.

R. J. EDEN

Manchester University, England

### Meeting Notes

- The 12th annual Conference on Protein Metabolism, which is sponsored by the Bureau of Biological Research of Rutgers University, will be held 27–28 Jan. The subtitle for the conference is "Amino acid supplementation."

# ON THE NATURE OF MAN

*An Essay on Primitive Philosophy*  
by DAGOBERT D. RUNES



#### ABOUT THE AUTHOR:

Dagobert D. Runes, received his Doctor of Philosophy degree from the University of Vienna. He is author and editor of numerous books and other publications, among them: *Dictionary of Philosophy* and *Treasury of Philosophy*. Among the many scientific journals he has edited are: *Journal of Aesthetics*, *Philosophic Abstracts*, *The Modern Thinker*. He is the former director of the Institute for Advanced Education.

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—Saturday Review

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The speakers and their topics are as follows: Edmund S. Nasset of the University of Rochester, "Essential amino acids and nitrogen balance"; Conrad A. Elvehjem of the University of Wisconsin, "The effects of amino acid imbalance on maintenance and growth"; Leon L. Miller of the University of Rochester, "Amino acid metabolism in the perfused liver"; Paul György of the University of Pennsylvania, "The liver in protein nutrition"; L. Emmett Holt, Jr., of New York University, "The amino acid pattern for children in health and in disease"; James B. Allison of Rutgers University, "Supplementation with methionine." All those interested in attending should write for registration blanks to William H. Cole, Rutgers University, New Brunswick, N.J.

■ The tenth annual Symposium on Fundamental Cancer Research will be held 29-31 Mar. at the University of Texas M. D. Anderson Hospital and Tumor Institute in the Texas Medical Center, Houston. A panel discussion on "Nucleic acid metabolism in tumors" will be under the direction of Van R. Potter, professor of oncology at the University of Wisconsin Medical School. Darrell Ward, department of biochemistry, M. D. Anderson Hospital, is in charge of the reports on recent developments in cancer research. Grant Taylor, dean of the University of Texas Post-graduate School of Medicine, is general chairman of the symposium.

■ The American Public Health Association's 83rd annual meeting, which took place in Kansas City, Mo., 14-18 Nov., gave public health practitioners on international, national, state, and local levels, "new perspective which should be invaluable in future program planning," according to Reginald M. Atwater, executive secretary of the association. The meeting, which was held in conjunction with meetings of 40 related organizations, was attended by 3501 public health workers from public and voluntary agencies and institutions in this country and abroad. Those attending the sessions were brought up to date on developments in the field by a display of 65 scientific exhibits and 82 technical exhibits.

The theme of the meeting, "Where are we going in public health?" was developed in two symposium sessions as well as in smaller meetings that were devoted to the present status and future trends of many specialized areas of health. The discussions pointed up mental health and care of the chronically ill as major problems of the future that undoubtedly will be emphasized during the association's 84th annual meeting in Atlantic City, N.J., 12-16 Nov. 1956.

Of special interest was an address by

former President Harry S. Truman in connection with presentation of the Albert D. Lasker awards of the APHA. Another feature was a symposium on practical experience with the Salk polio vaccine in which many of the key figures in the development and utilization of the vaccine participated, including Jonas E. Salk and Leonard A. Scheele.

The association cited the following for the excellence of scientific exhibits: the Missouri Division of Health, the Division of International Health of the U.S. Public Health Service together with the Public Health Division of the International Cooperation Administration, the Equitable Life Assurance Society of the United States, the U.S. Public Health Service, the Metropolitan Life Insurance Company, the Canadian Department of National Health and Welfare, the American Dietetic Association, the National Sanitation Foundation, the Pan American Sanitary Bureau, World Health Organization, and the Health Insurance Plan of Greater New York. In addition, special recognition was given to a health-careers exhibit that was sponsored jointly by the National Health Council and the Equitable Life Assurance Society of the United States.

■ A symposium on Perspectives in Marine Biology will be held at the University of California's Scripps Institution of Oceanography 24-31 Mar. under the joint sponsorship of the Office of Naval Research and the Scripps Institution. The symposium has been officially approved by the International Union of Biological Sciences.

Discussion will center on potential developments in marine biology rather than on past accomplishments. Among the participants will be the following: from abroad, E. Baldwin, C. Barigozzi, H. Barnes, C. Boquet, P. Dohrn, P. Drach, J. Hämmenling, A. C. Hardy, S. K. Kon, R. Margalef, Y. Matsui, D. Miyadi, G. Montalenti, R. J. Pumphrey, K. M. Rae, A. Remane, R. Riedl, W. Rodhe, W. H. Thorpe, G. Thorson, V. and L. Tonolli, D. P. Wilson, C. M. Yonge, L. Zenkovich, and E. Zeuthen; from the United States, D. I. Arnon, L. R. Blinks, F. A. Brown, T. H. Bullock, E. W. Caspari, E. S. Guzman Barron, A. D. Hasler, G. E. Hutchinson, V. L. Loosanoff, D. Mazia, A. Novick, C. S. Pittendrigh, C. L. Prosser, L. Provasoli, D. L. Ray, A. C. Redfield, F. K. Skoog, S. Spiegelman, H. Staiger, R. Y. Stanier, A. Szent-Györgyi, L. Szilard, T. H. Waterman, W. Weiser, and P. Weiss.

Accommodations are available for approximately 25 additional participants. Some of these may be graduate students in biology, who may attend upon recommendation by the heads of their departments and upon acceptance by the

Scripps Institution; some financial support will be made available to graduate students.

The proceedings will be published by the University of California Press. Persons wishing to attend should write to: A. A. Buzzati-Traverso, Scripps Institution of Oceanography, La Jolla, Calif.

## Forthcoming Events

### January

26-27. Engineers Joint Council General Assembly, New York. (Engineering Manpower Commission, EJC, 29 West 39 St., New York 18.)

26-27. Western Spectroscopy Assoc. 3rd annual, Berkeley, Calif. (J. W. Ottos, Shell Development Co., Emeryville, Calif.)

27-28. Conf. on Protein Metabolism, 12th annual, New Brunswick, N.J. (W. H. Cole, Rutgers Univ., New Brunswick.)

27-28. Western Soc. for Clinical Research, 9th annual, Carmel-by-the-Sea, Calif. (A. J. Seaman, Univ. of Oregon Medical School, Portland 1.)

30-1. International Conf. on Fatigue in Aircraft Structures, New York, N.Y. (A. M. Freudenthal, 716 Engineering, Columbia Univ., New York 27.)

30-3. American Inst. of Electrical Engineers, New York, N.Y. (N. S. Hibshman, AIEE, 33 W. 39 St., New York 18.)

31-3. American Soc. of Sugar Beet Technologists, 9th biennial conf., San Francisco, Calif. (Western Beet Sugar Producers, Inc., 461 Market St., San Francisco 5.)

31-4. American Physical Soc., New York, N.Y. (K. K. Darrow, Columbia Univ., New York 27.)

### February

1. National Advisory Committee on Local Health Depts., 8th annual, New York, N.Y. (National Health Council 1790 Broadway, New York 19.)

1-2. Armour Research Foundation Midwest Welding Conf., Chicago, Ill. (H. Schwartzbart, Armour Research Foundation, Illinois Inst. of Technology, Chicago 5.)

1-3. Case Studies in Operations Research, Cleveland, Ohio. (Operations Research Group, Dept. of Engineering Administration, Case Inst. of Technology, 10900 Euclid Ave., Cleveland 6.)

2-3. National Symposium on Microwave Techniques, Philadelphia, Pa. (S. M. King, Inst. of Radio Engineers, 1 E. 79 St., New York 21.)

5-8. National Citizens' Planning Conf., Washington, D.C. (Miss H. James, 901 Union Trust Bldg., Washington 5.)

9-10. Soc. of American Military Engineers, annual, Chicago, Ill. (D. A. Sullivan, 72 W. Adams St., Chicago 90.)

13-17. American Soc. of Civil Engineers, Dallas, Tex. (ASCE, 33 W. 39 St., New York 18.)

16-17. National Conf. on Transistor Circuits, 3rd, Philadelphia, Pa. (J. D.

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19-23. American Inst. of Mining and Metallurgical Engineers, New York, N.Y. (E. O. Kirkendall, AIME, 29 W. 39 St., New York 18.)

19-23. Soc. of Economic Geologists, New York, N.Y. (O. N. Rove, Union Carbide and Carbon Corp., New York 17.)

20-22. American Educational Research Assoc., annual, Atlantic City, N.J. (F. W. Hubbard, AERA, 1201 16 St., NW, Washington 6.)

23-25. National Soc. of College Teachers of Education, Chicago, Ill. (C. A. Eggertsen, School of Education, Univ. of Michigan, Ann Arbor.)

24-25. American Physical Soc. Houston, Tex. (K. K. Darrow, APS, Columbia Univ., New York 27.)

26-29. American Inst. of Chemical Engineers, Los Angeles, Calif. (F. J. Van Antwerpen, AIChE, 25 W. 45 St., New York 36.)

28-29. Scintillation Counter Symposium, 5th, Washington, D.C. (G. A. Morton, RCA Laboratories, Princeton, N.J.)

### March

12-16. National Assoc. of Corrosion Engineers, 12th annual, New York, N.Y. (Secretary, NACE, Southern Standard Bldg., Houston 2, Tex.)

14-17. National Science Teachers Assoc., Washington, D.C. (R. H. Carleton,

NSTA, 1201 16 St., NW, Washington 6.)

15-16. Food Physics Symposium, 1st international, San Antonio, Tex. (C. W. Smith, Southwest Research Inst., San Antonio.)

15-17. American Orthopsychiatric Assoc., 33rd annual, New York, N.Y. (M. F. Langer, AOA, 1790 Broadway, New York 19.)

15-17. American Physical Soc., Pittsburgh, Pa. (K. K. Darrow, APS, Columbia Univ., New York 27.)

15-17. Kappa Delta Pi, annual, Stillwater, Okla. (E. I. F. Williams, 238 E. Perry St., Tiffin, Ohio.)

16-18. International Assoc. for Dental Research, St. Louis, Mo. (D. Y. Burrill, 129 E. Broadway, Louisville 2, Ky.)

18-24. American Soc. of Photogrammetry, annual, joint meeting with American Cong. on Surveying and Mapping, Washington, D.C. (ACSM-ASP, Box 470, Washington 4.)

19-22. American Acad. of General Practice Scientific Assembly, 8th annual, Washington, D.C. (AAGP, Broadway at 34th, Kansas City 11, Mo.)

19-22. Inst. of Radio Engineers National Convention, New York. (E. K. Gammatt, IRE, 1 E. 79 St., New York 21.)

19-23. American Soc. of Tool Engineers, Chicago, Ill. (H. C. Miller, Armour Research Foundation, 35 W. 33 St., Chicago 16.)

21-22. National Health Forum, New York, N.Y. (T. G. Klumpp, National

Health Council, 1790 Broadway, New York 19.)

21-23. American Power Conf., 18th annual, Chicago, Ill. (R. A. Budenholzer, Illinois Inst. of Technology, Chicago 16.)

21-24. American Astronomical Soc. Columbus, Ohio. (J. A. Hynek, McMillin Observatory, Ohio State Univ., Columbus 10.)

23-24. Eastern Psychological Assoc., Atlantic City, N.J. (G. G. Lane, Univ. of Delaware, Newark.)

24-25. American Psychosomatic Soc., 13th annual, Boston, Mass. (T. Lidz, APS, 551 Madison Ave., New York 22.)

24-31. Perspectives in Marine Biology, La Jolla, Calif. (A. A. Buzzati-Traverso, Scripps Institution of Oceanography, La Jolla.)

25-28. American Assoc. of Dental Schools, annual, St. Louis, Mo. (M. W. McCrea, 42 S. Greene St., Baltimore 1, Md.)

25-29. American College Personnel Assoc., Washington, D.C. (Miss C. M. Northrup, Univ. of Denver, Denver, Colo.)

28-3. Colloquium on Frontiers in Physical Optics, Boston, Mass. (S. S. Ballard, Visibility Laboratory, Scripps Institution of Oceanography, San Diego 52, Calif.)

29-31. Pennsylvania Acad. of Science, Indiana. (K. Dearolf, Public Museum and Art Gallery, Reading, Pa.)

(See 16 Dec. issue for comprehensive list)

## Equipment News

■ **MULTICHANNEL ANALYZER** that uses the gated method of operation is adaptable to both coincidence and anticoincidence spectrum analysis. The instrument was developed for obtaining alpha, beta, or gamma pulse height analyses from samples with a wide range of activity levels. Sufficient stability is provided to permit 5-day runs on weak samples; short resolving times are available to permit the handling of hot samples. Resolving time for counts in the same channel is 500  $\mu$ sec; over-all resolving time is 10  $\mu$ sec. The analyzer utilizes four-digit, electrically resettable registers and scale-of-ten glow transfer tubes. The servo regulated power supply and amplifier are designed for operation with either a scintillation spectrometer or a Frisch grid chamber. Two to five discriminator chassis, each providing ten channels, can be used. (Tracerlab, Inc., Dept. Sci., 130 High St., Boston 10, Mass.)

■ **IONIZING UNITS** in strengths of 250, 500, and 1000  $\mu$ c consist of strips of polonium mounted in stainless steel housing and are designed to be used to neutralize static electricity. Size of each unit is  $2\frac{1}{2}$  by  $\frac{1}{2}$  by  $7/32$  in. (Nuclear Products Co., Dept. Sci., 10173 E. Rush St., El Monte, Calif.)

■ **WINDOWLESS FLOW COUNTER** is an internal sample counter that may be used for both Geiger and proportional counting of solid samples. A continuous flow of appropriate counting gas must be maintained through the instrument. The physical arrangement of the sample in the chamber makes it possible to achieve full  $2\pi$  geometry. The instrument is designed for counting alpha particles or low-energy betas from such isotopes as carbon-14 and sulfur-35. (Packard Instrument Co., Dept. Sci., P.O. Box 428, LaGrange, Ill.)

■ **X-RAY MOTION PICTURE EQUIPMENT** designed by J. S. Watson and S. A. Weinberg of the University of Rochester Medical Center is being manufactured by the General Electric Co. The apparatus has been designed for use with conventional x-ray equipment; it can be used with either 16 or 35 mm film; speed range is  $3\frac{1}{2}$  to 30 frames/sec. An electronic triggering mechanism synchronizes the x-rays with the camera. (General Electric Co., X-ray Department, Dept. Sci., Milwaukee, Wis.)

■ **MAGNETIC REFRIGERATOR** that operates on the cyclic technique of magnetic cooling will maintain any temperature within the range of  $1^{\circ}$  to  $0.25^{\circ}\text{K}$ . The system consists of a paramagnetic salt and the

reservoir to be cooled, suspended in an evacuated chamber that is immersed in a liquid helium bath. Operation is controlled entirely by external magnetic fields. (Arthur D. Little, Inc., Dept. Sci., 30 Memorial Dr., Cambridge 42, Mass.)

■ **ANALYZER FOR LIGHT HYDROCARBON GASES** under normal temperature and pressure, the Fracton, separates, identifies, collects, and measures the components and records data. The instrument operates by the method of absorption fractionation. Operation is largely automatic. Booklet 82. (Burrell Corp., Dept. Sci., 2223 Fifth Ave., Pittsburgh 19, Pa.)

■ **FINENESS TESTER** that operates on the air permeability method is designed for use with Portland cement, pharmaceutical powders, and other granular materials. Bulletin 233. (Precision Scientific Co., Dept. Sci., 3737 W. Cortland St., Chicago 47, Ill.)

■ **MILLIPORE FILTERS** are described in a new edition of the Millipore catalog. Retention, flow characteristics, solubility, chemical resistance, capillarity, and other properties are presented. Various microbiological, microchemical, and microphysical applications are reported. (Millipore Filter Corp., Dept. Sci., Watertown 72, Mass.)

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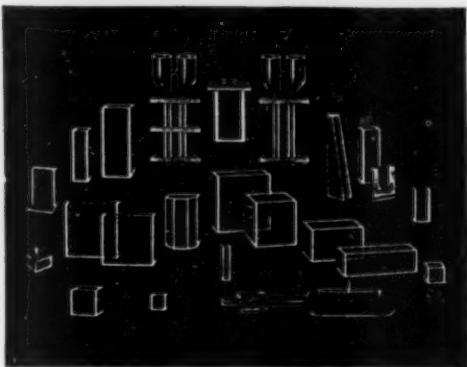
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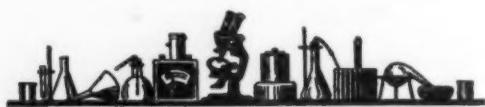
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